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Sounder Update and Field Strength Software Modifications for Special Operations Radio Frequency Management System (SORFMS)

Volume 1: Program Descriptions and Testing

Systems Exploration, Inc.

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ADMINISTRATIVE INFORMATION

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FS

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SECTION 1
GENERAL INFORMATION

1.1 OBJECTIVE

The purpose of this document is to provide information about the Special Operations Radio Frequency Management System (SORFMS) model enhancements produced by Systems Exploration, Inc. The enhancements include the incorporation of a Sounder Update (SU) model and an improved version of the Field Strength (FS) model. The SU model is an adaptation and translation to FORTRAN of the Army PROPHET Evaluation System (APES) BASIC model. The FS enhancements involve modification of the field strength modeling algorithms, consequential to efforts to improve the accuracy of this model.

SORFMS will be run on a Grid Compass computer or any of a family of IBM compatibles. The SORFMS upgrades were developed, integrated and tested on an HP 9050 computer. Since the source code is FORTRAN 77, it can be transported to the hardware environment with little or no modification. However, since there are no facilities for comprehensive testing in this environment, it is the HP 9050 version that is described herein. The HP 9050 software is referred to as High Frequency Tactical Decision Aids (HFTDA) or simply TDA.

The methodology of using the HP 9050 as a developmental tool for software destined for the Grid Compass and IBM compatibles is modeled after a similar method used for developing Advanced PROPHET (AP). Similarities among SORFMS, AP and TDA have been exploited wherever applicable.

This document is addressed to analysts and maintenance programmers who must understand the rationale and details of these enhancements, exercise the functions, and integrate these new features with additional changes to the programs produced at NOSC. For continuity among the relevant documents (listed in 1.5), Section 1 herein provides an overview of SORFMS.

1.2 BACKGROUND

The SORFMS is a small, lightweight, stand alone and highly transportable real time propagation assessment and forecasting system which defines natural propagation constraints on HF transmissions and outputs this data in an easily interpreted format. The system includes an HF transmitter, HF receiver, spectrum monitor, frequency management terminal, and a portable computer. The system software, described herein, is installed on the portable computer

The SORFMS software is a collection of computer simulation models developed to support tactical use of the HF band (2 - 32 MHz). Primarily, SORFMS can determine the existence of an HF skywave channel between two sites anywhere in the world; it can also determine the potential for a hostile force to intercept the transmission, radio locate the transmitter, or jam the reception site. For short-range circuits, a groundwave model is included; this along with ~~the~~ skywave model, can be exploited to provide (for example) covert communications between closely operating units.

In SORFMS, most adjustable parameters can be preset and will be accessed automatically as needed. There are a few parameters that must be continually adjusted, and these are the solar/geophysical constants that drive the computer models. The Sounder Update (SU) model is used to update a pseudo-sunspot number and is included in this category. For normal operation, these parameters are input in near real time. However, for planning purposes or to analyze past performance on a circuit, estimated or historical data can be used.

Reference 1, paragraph 1.2.1 provides a detailed summary of the physics of HF propagation. This particular reference describes Advanced PROPHET; however, the physical description is directly applicable to SORFMS.

1.3 SUMMARY

The enhancements to the SORFMS described in Section 2 include:

a. Addition of a SU model. The model was derived from APES and translated from BASIC to FORTRAN. The 'SU' command was added to the AP command menu so that it is accessible to the operator.

b. Modification of the FS model to provide more accurate data outputs. Specifically, the FS model now provides outputs which can be more closely correlated with the CCIR data base.

1.4 ENVIRONMENT

1.4.1 Hardware

SORFMS is targeted to operate on the GRID Compass computer, IBM PC and compatibles. The SORFMS modules described herein were developed on the HP 9050 computer.

A version of Advanced PROPHET (called TDA) runs on the HP 9050 system at NOSC. This system was used as a test bed for development and test of the SORFMS SU and FS modules. The adaptation of the 9050 program to the GRID Compass/IBM PC and compatibles environment entails the tranferrance of the FORTRAN source code to a machine which can compile into GRID Compass machine code.

1.4.2 Software

SORFMS is configured to run under the MS-DOS operating system, Version 2.0, or greater. The TDA development system runs under the UNIX operating system.

1.5 REFERENCES

1. NOSC TD 848, Operational Users Manual for Advanced PROPHET on MS-DOS-BASED Microcomputer Systems, by R. W. LaBahn, August 1985.

2. NOSC TD 1065, Operational User's Manual for Tactical Decision Aids for HF Communication, by D.B. Sailors, July 1987.

3. Integrated Logistic Support Plan (ILSP) for Special Operation Radio Frequency Management System (SORFMS) (Draft), prepared by U.S. Army Communications Electronics Command, COMM/ADP Center, Fort Monmouth, NJ, September 1986.

4. NOSC TD 782, Tactical Decision Aids for HF Communication, by D.B. Sailors, 15 November 1984.

5. NOSC Contractor Report, Program Package Document for Sounder Update and Field Strength Software Modifications for Special Operations Radio Frequency Management System (SORFMS), prepared for D. B. Sailors, by J. R. Gnessin, D. J. Brandon, and D. L. Lucas, Systems Exploration, Inc., March 30, 1988. (NOSC TD 1848, Volume 2)

SECTION 2
PROGRAM DESCRIPTIONS

2.1 OVERVIEW

The Sounder Update (SU) and Field Strength (FS) modules of SORFMS, described in this section, are separate modules in the sense that each is independently invoked by the operator. However, most of the modules of SORFMS are interrelated in the sense that they use common routines, and in some cases, the outputs of one module may affect the operation of another, depending upon the sequence selected. The case in point is SU, where the sunspot number produced by the SU module is one of the parameters used by the FS module.

The SU and FS modules invoke many standard subroutines and library routines previously existing in TDA which were not modified and are thus not described in detail here, other than references when they are used. Subroutines DAMBOLT and MUF85 were modified slightly to accommodate the new LTLFLD algorithm. However, changes did not affect the algorithms, functionality, or compatibility with the remainder of the modules with which they interface. Therefore, these subroutines are not described here. However, for configuration management purposes, their source code listings are included with the listings in the SORFMS Program Package Document (reference 6, listed in paragraph 1.5).

2.2 FIELD STRENGTH (FS)

2.2.1 Scope

2.2.1.1 Identification

PROGRAM FSTREN

2.2.1.2 Engineer

D. L. Lucas

2.2.1.3 Purpose

This program, and its associated subroutines, provides a method for the rapid assessment of HF skywave signal quality as a function of frequency within the propagation bandwidth for links between specified points on the earth's surface.

2.2.1.4 Background

The computer module development to replace "DAMBOLT" long path model for paths shorter than 7000 KM is a model relying on propagation via the regular E-layer (reference 1) and the F2-layer (reference 2). The routine finds a lower order mode for the E-layer, F2-layer, and a mixed E-layer and F2-layer mode. Only one E-layer hop is considered in the mixed mode. The remaining hops are F2-layer, either below or above the MUF for the path.

The MUF model used is that of HFTDA (MINIMUF-85) for the F2 layer. The MUF for the E-layer is calculated as in IONCAP (reference 3). E-layer MUFs at night cannot be lower than 700 KHz (reference 1). The ionospheric absorption equation is the one used in IONCAP with the near specular reflection losses calculated for E-layer modes at low frequencies. The over-the-MUF losses (reference 4) are calculated using the Phillips method for values of the Freq/MUF ratio of approx. 1.4 to approx. 1.5 depending on ground distance, with values greater being considered in the "scatter" region. The losses above these values are estimated as in IONCAP which was taken from some work of JTAC (references 5,6). This means the over-the-MUF losses are a function of season, sunspot, geomagnetic latitude, local time, and path length since the distribution of the MUFs used are a function of these variables.

The value of the Absorption Index I at night has a value which is a function of solar activity, which was taken from the work of Wakai (reference 7). The value perviously used in IONCAP was from earlier data at high solar activity (I .ge. .1). This meant the absorption was constant at nighttime hours for a given operating frequency on a given path and solar activity.

The minimum-hop predicted for the E layer is calculated for an h'E of 110 KM and the path length. The radiation angle associated with this mode must have an angle greater than some predetermined minimum. If not dictated by the user, the angle is assumed to be at the horizon, i.e., zero degrees.

The minimum F2-layer hop must be above some pre-set value for the take-off angle as for the E-layer and also penetrate the E layer at the F2-layer angle calculated using h'F2 as calculated in HFTDA. The F2-layer hops are increased until one satisfies the above restrictions.

The mixed mode is calculated using the E-layer height (110 KM) and the h'F2 to determine a take-off angle. The frequency must be supported by the E-layer at one end of the path and penetrate at the other end for this mode to be possible. One E-layer hop is permitted and the path completed with F2-layer hops depending on path length.

Only one minimum hop is chosen for each mode of propagation since the antennas are only chosen by operating frequency and path length making discrimination between a 1 hop and 2 hop path not practical until more realistic antenna patterns are used. The value of the transmission loss used to predict the fields is the loss associated with the mode of least loss, i.e., they are assumed to be uncorrelated.

All losses calculated are a function of geomagnetic latitude, length of path, time of day and season since the system loss tables of IONCAP (reference 3) are used in the module along with the distribution of the MUFs (reference 3). The routine LTLFLD is highly modular allowing changes in the predicted parameter with some ease.

The ease in changing methods of calculating these parameters also allowed for changes in over-the-MUF (reference 8), low frequency short-paths and radiation angles to improve the RMS prediction error.

2.2.1.5 Restrictions and Limitations

The module LTLFLD is built around analytical methods and empirical data in the range of three to thirty MHz. Any calculations or predictions outside this range should be considered highly suspect.

Sunspot numbers over 150 should be used with caution since the critical frequencies of the F2-layer (FoF2) are more related to where you are within a given cycle rather than the absolute sunspot number. In other words depending on cycle the FoF2 may not increase from sunspot 150 to say 200. Some scientists believe a saturation effect takes place.

The predictions are hourly-medians of the monthly medians correlated with monthly median running average sunspot number (RASSN) and much care should be taken when predicting for a given day or a few days ahead. Field strength predictions are weakly associated with daily values of solar activity.

Solar flux data which are used as an indicator of ionization in the F2-layer may or may not effect in the same manner the E- and D-layer which controls most non-deviative absorption calculated by this method. Correlation coefficients are not available for the D-, E-, and F2-layer to warrant daily predictions of the field strength. The accuracy of the prediction routine; therefore, depends entirely upon its intended use, i.e., frequency assignment in the long term, siting, antenna selection, day-to-day frequency use, absolute signal determination, etc.

Care should always be taken to not use the tool beyond its intended use.

2.2.1.6 Language

HP FORTRAN/77

2.2.1.7 Computer Configuration

HP 9000 Series 500 HP-UX (HP 9050)

2.2.1.8 Models Referenced

None

2.2.2 Numeric Method

The method for predicting field strength at the receiving location using module LTLFLD is the solution of "Norton's" transmission loss equation (reference 9).

The system loss equation in terms of resulting field strength is:

$$Ef = 107.2 + Pt + Gt + 20\log f - Lbf - Li - Lm - Lg - Lh$$

where: $Lbf = 32.45 + 20\log F + 20\log P'$
- f = operating frequency (MHz)
- P' = virtual slant range (KM) (reference 1)
- Pt = effective radiated power in same units as received power (Watts)
- Li = ionospheric absorption loss below MUF (dB) (reference 1)
- Lg = ground reflection losses at intermediate reflection points (dB) (taken as 2 dB per ground reflection)
- Gt = antenna power gain relative to isotrope in free space (dB)
- Lm = over-the-MUF loss (dB) (reference 4)
- Lh = excess system loss to allow for auroral, sporadic-E obscuration and other losses not explicitly included in the predictions (dB) (reference 1)

The above losses are calculated separately and are unique allowing any specific loss calculation to be changed without affecting the others. LTLFLD is merely a solution to the above equation.

The ionospheric absorption equation used is that of ITSA-1 (reference 1) revised to account for nearly specular reflection at low frequencies in the day-time hours as in Radar-C (reference 4).

The E-layer critical frequencies (FoE) are calculated using the absorption index "I" as in ITSA-1.

The simplist calculations were used to increase speed of calculation as accuracy was assumed not to suffer for medion values and field strength calculations alone. Fourier series expansions representing the predicted ionospheric coefficients are not included in any of the variables.

2.2.3 Module Design Description

2.2.3.1 Required Input

User entries:

1. Date of model run (set by the TDA command 'DA') and stored in variables MONTH, JDAY, YEAR.

2. Sun spot number (SSN) of model run (set by the TDA command 'SS').

3. Transmitter site parameters for the site (e.g., hono for Honolulu) including the site latitude (STALAT(K+X)), longitude (STALON(K+X)), antenna type (STAANT(K+X)), and power (STAPWR(K+X). (Values set by the TDA command 'AS').

4. Receiver site parameters for the site (e.g.,sdiego for San Diego) including the site latitude (STALAT(K+X)), longitude (STALON(K+X)), antenna type (STAANT(K+X)), and power (STAPWR(K+X)). (Values set by the TDA command 'AS').

5. Atmospheric Noise (ATMOS) (set by the TDA command 'AT').

6. Signal-to-noise ratio (SIGNSE) (set by the TDA command 'SN').

2.2.3.2 Processing

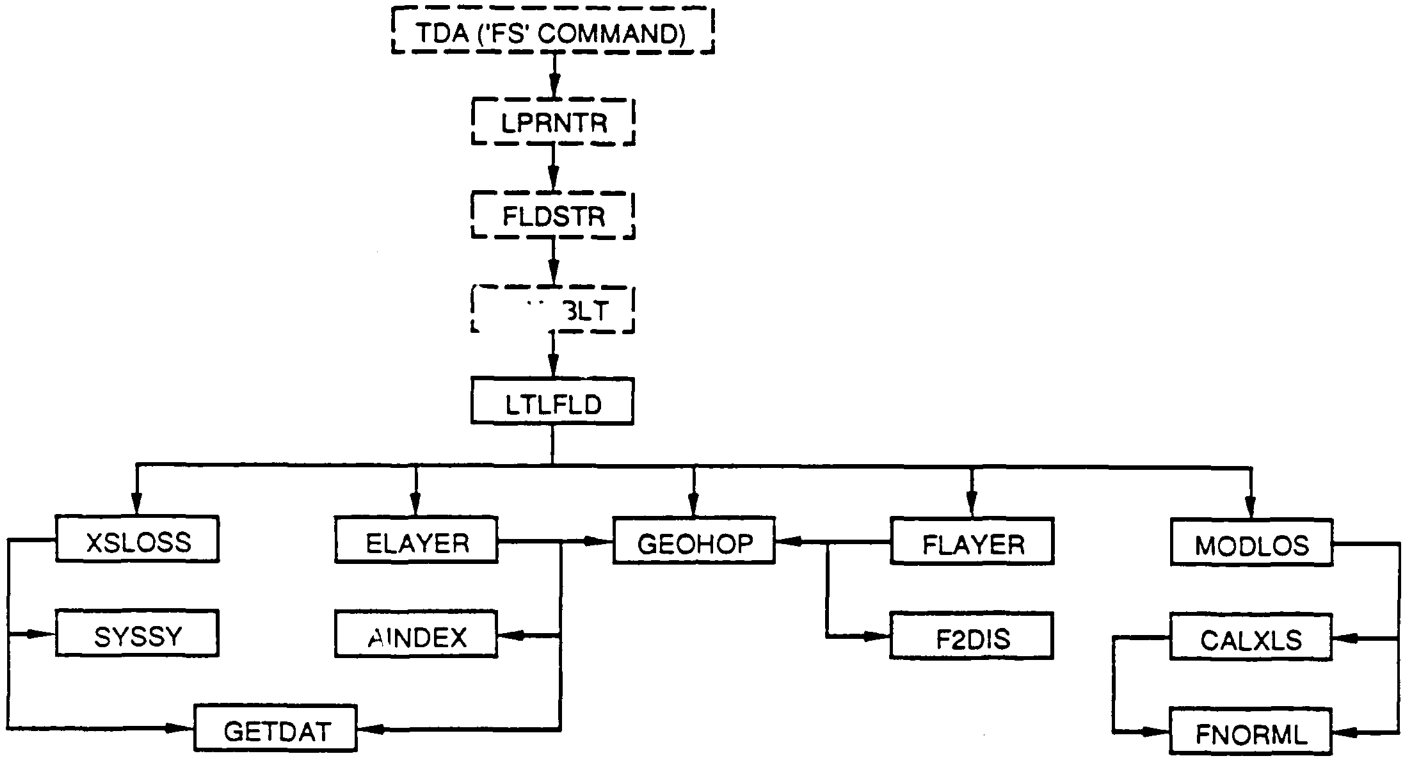
The Field Strength module consists of a program and subroutines. The program is invoked via the executive routine in TDA upon entry of the FS command by the operator. On completion of processing, the TDA is invoked once again and control is returned to the TDA executive.

Figure 1 shows both the hierarchical structure and calling sequence of the routines with the Field Strength module. Arrows point to the called routine from the calling routine. Each call is not indicated, and in general does not follow the same pattern.

2.2.3.3 Output

The output of the Field Strength module is a table (and/or plot) of the field strength in dB for the specified path and date. Field strength is provided as a function of of frequency and time. Frequencies range from 2 to 30 MHz and time is over a 24 hour period.

OVERALL CALLING STRUCTURE



ARROWS POINT TO THE CALLED ROUTINE FROM THE CALLING ROUTINE. EACH CALL INCLUDES ARGUMENTS. DATA COMMUNICATED THROUGH COMMON IS NOT INDICATED, AND IN GENERAL DOES NOT FOLLOW THE SAME PATTERN.

Figure 1. Field Strength Module Hierarchy and Calling Sequence

2.2.4 Subprogram Design Descriptions

2.2.4.1 Subroutine LTFLD

2.2.4.1.1 LTLFLD inputs

Call variables

FREQ	current operating frequency (MHz)
CPNT	control point array as defined in MUF85 (deg & KM)

Common variables

PWRWAT	transmitter power (watts)
SF2MUF	F2-layer MUF from MUF85 (MHz)
IFHOPS	minimum F-layer hops
HPF2	virtual height of F-layer from MUF85 (KM)
MISC(1)	current month

2.2.4.1.2 LTLFLD Processing

a. Figure 2 illustrates the flow of LTLFLD. Following the declarations, data is initialized and local variables assume values of corresponding global variables. Subroutines ELAYER, FLAYER, and XSLOSS are called in sequence to compute E layer MUF (EMUF), absorption index (ABSI), and critical frequency (FOF2).

b. If the frequency is less than 1.4*EMUF, some E layer reflection is assumed and subroutine MODLOS is called to compute the transmission losses associated with this mode. If the frequency is equal to or greater than 1.4*EMUF, then no E mode reflection is computed for these conditions. After calling MODLOS, LTLFLD corrects for partial penetration of the E layer and totals the transmission losses; field strength is obtained for this mode.

c. FREQ is tested against the frequency necessary to penetrate the E layer (E penetration frequency is FOEMIN*SECD(2)*1.05). If FREQ is high enough to get through, calculate an F mode by calling MODLOS with F arguments; otherwise, FHOPS is increased and a new geometry is obtained via GEOHOPS to try again. Up to three tries are permitted.

d. If FHOPS > 1 a mixed mode (1E-NF) propagation path can exist. Assume total hops equal to FHOPS, one of which will be an E hop. Calculate a weighted average height and get remaining geometry from GEOHOP. Test that the ray path will penetrate the E layer at one end (F mode result), but not the other (E mode). If true, a mixed mode exists; calculate its characteristics via MODLOS. If no such mode exists, go to last step.

e. Finally, LTLFLD sets the predicted field strength to the greatest of those determined thus far. The last thing to do is check the calculated E-layer MUF against the F-layer MUF from

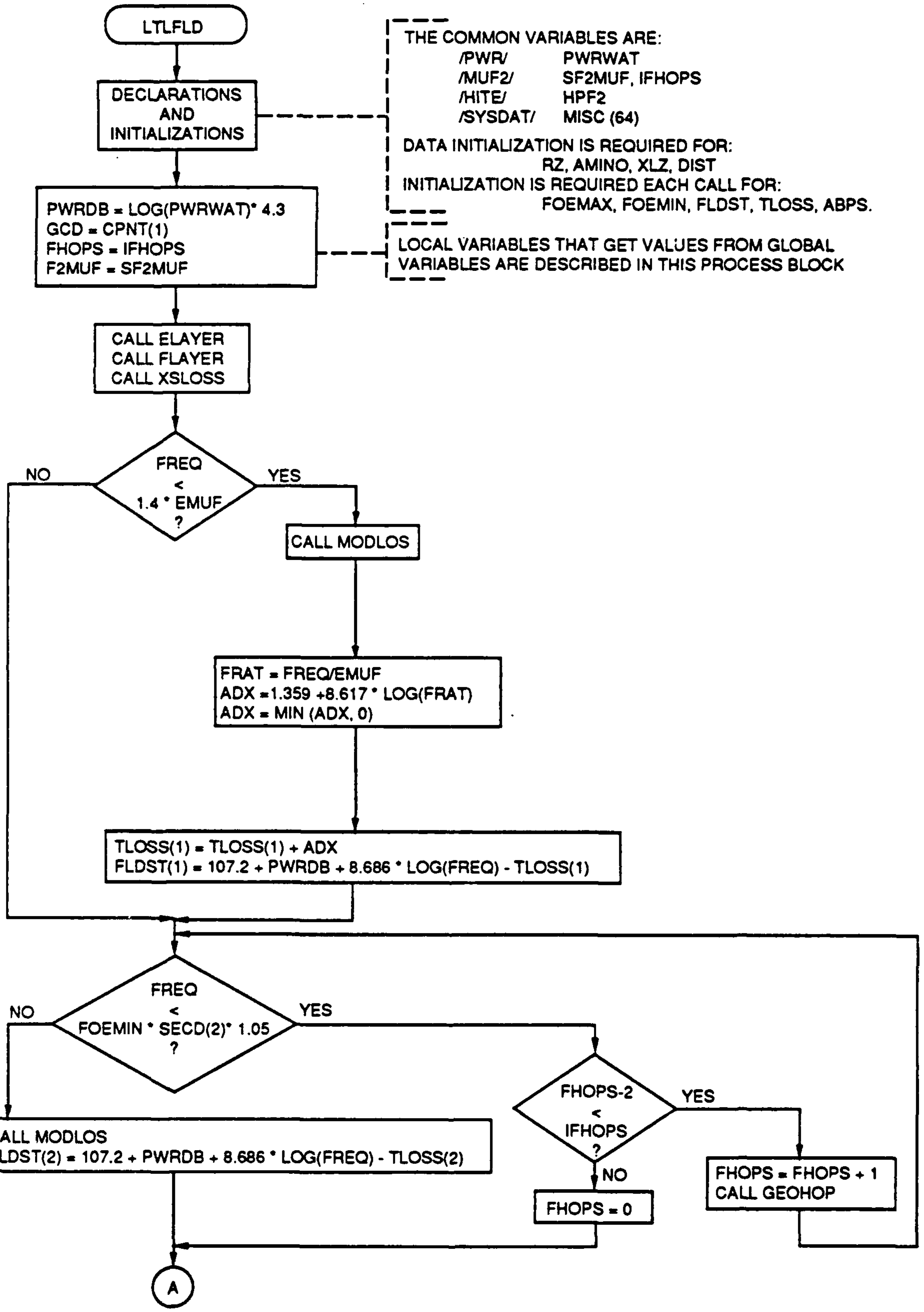


Figure 2. Subroutine LTLFLD (Sheet 1 of 2)

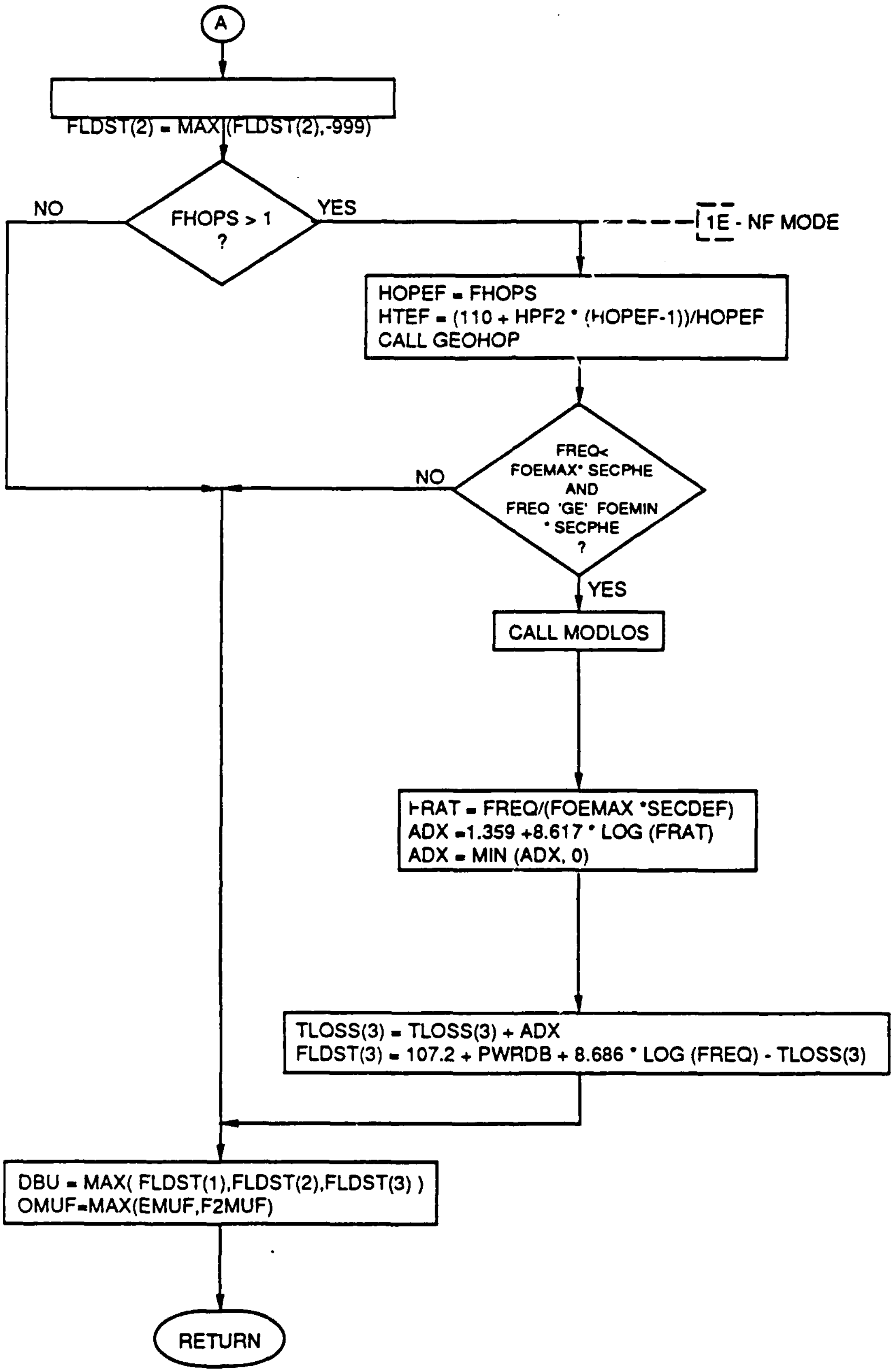


Figure 2. Subroutine LTLFLD (Sheet 2 of 2)

MUF85. Return the greater of the two in variable OMUF. Note that in this case, OMUF is not the "operational MUF" as used in Damboldt's work, but the higher of the E- and F-LAYER MUFs resulting from different prediction methods.

Important variables local to LTLFLD are listed below:

PWRDB	transmitter power (dBW)
GCD	great circle distance (radians)
FHOPS	number of hops for F mode propagation
F2MUF	F layer MUF from MUF85
ADX	correction for E layer penetration
TLOSS	transmission loss
FLDST	predicted field strength
HOPEF	number of hops for mixed E-F propagation
HTEF	weighted average height mixed mode
EMUF	E-layer MUF as predicted in ELAYER
ABSI	This variable occurs in several subroutines, with the same name, and is the absorption index
FOEMIN	minimum FOE found along path
FOEMAX	maximum FOE found along path
SECD	the secant of the angle of incidence of a ray path with D region ionization height (100 km) for E and F modes
FHOPS	the number of F mode hops
SECPHE	secant of phi with the E,F layers
SECDEF	secant of phi with the D region ionization for mixed modes

2.2.4.1.3 LTLFLD outputs

DBU	field strength (dBU>1uV/M)
OMUF	classical MUF (MHz) (E or F2-layer)

2.2.4.2 Subroutine ELAYER

2.2.4.2.1 ELAYER inputs

Call variables

SSN	sunspot number (Zurich running average)
GCD	great circle distance, transmitter to receiver (KM)
FOEMIN	minimum FOE of all control points used (MHz)
FOEMAX	maximum FOE of all control points used (MHz)

Common variables

CONNUM	the number of control points in use
D2R	factor for converting degrees to radians

2.2.4.2.2 ELAYER processing

Figure 3 illustrates the flow of subroutine ELAYER. The primary purpose of this subroutine is to compute the values of the E-layer MUF (EMUF). Other associated outputs are listed in 2.2.4.2.3.

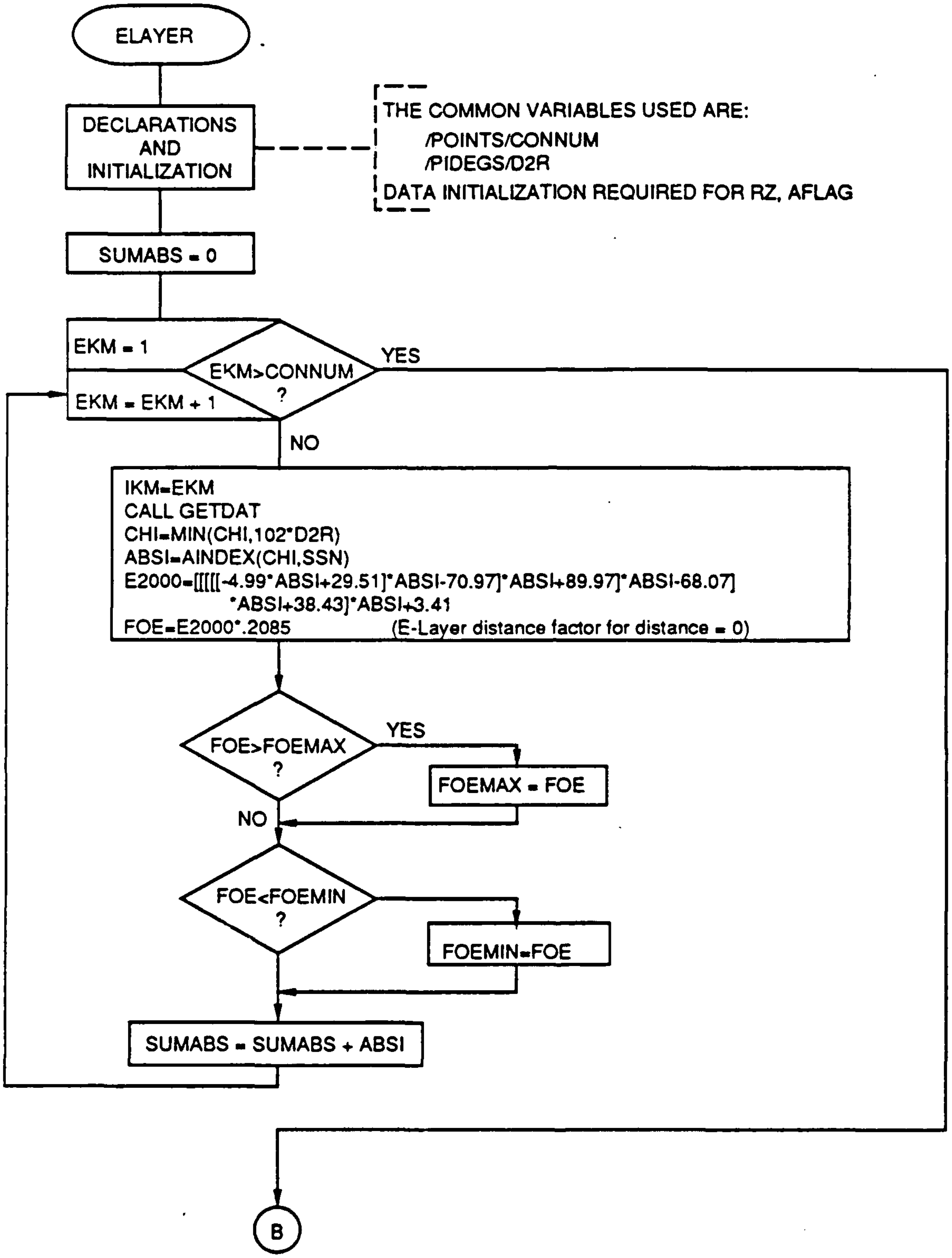


Figure 3. Subroutine ELAYER (Sheet 1 of 2)

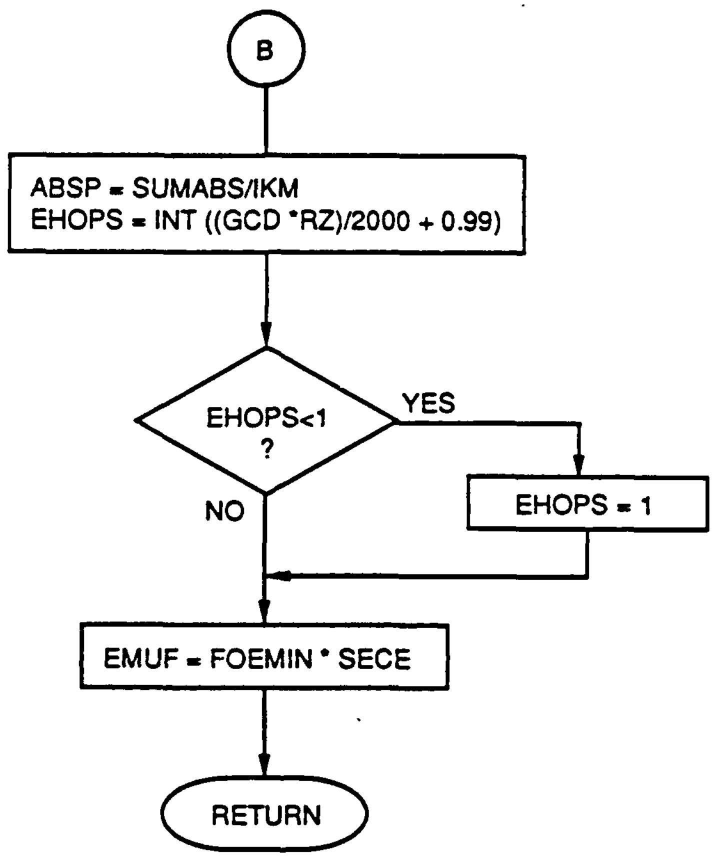


Figure 3. Subroutine ELAYER (Sheet 2 of 2)

Significant local variables are listed below:

CHI	solar zenith angle
AESP	An average value for ABSI across the path
FOE	E layer critical frequency

2.2.4.2.3 ELAYER outputs

EHOPS	number of E-mode hops for this geometry
ABSI	absorption index
FOEMIN	minimum FOE of all control points used (MHz)
FOEMAX	maximum FOE of all control points used (MHz)
EMUF	E-layer MUF (MHz)
DELE	take-off angle associated with this mode (deg)
SECE	secant(phi) at E-layer (110 KM) for this DELE
DGYRO	gyro frequency at D height (100) (MHz)
SECD	secant(phi) at D-layer (100 KM) for this geometry (KM)
PATHE	total slant distance of the path for this geometry (KM)
ABSP	average absorption index

2.2.4.3 Subroutine FLAYER

2.2.4.3.1 FLAYER inputs

Call variables

FHOPS	number of F-mode hops for this geometry
GCD	great circle distance, transmitter to receiver (KM)
HPF2	virtual height of F2-layer (KM)
F2MUF	F2-layer MUF (MHz)
SSN	sunspot number (Zurich running average)
FREQ	current frequency (MHz)
MONTH	current month

Common variables

CONNUM	the number of control points in use
CONLAT	array of control point geographic latitudes (deg N & S)
CONLMT	array of control point local mean times (hours: 0:23)

2.2.4.3.2 FLAYER processing

Figure 4 illustrates the flow of subroutine FLAYER. The primary purpose of this subroutine is to compute the value of the critical frequency of the F2-layer, FOF2. Other associated ouptuts are listed in 2.2.4.3.3.

There are no significant local variables.

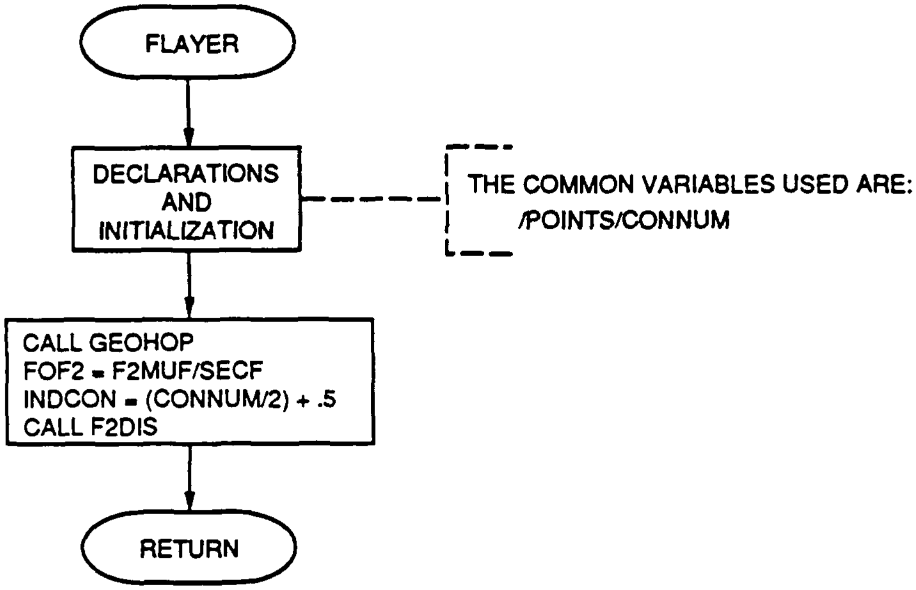


Figure 4. Subroutine FLAYER

2.2.4.3.3 FLAYER outputs

SECF	secant(phi) at F2-height for this geometry
FOF2	critical frequency of F2-layer (MHz)
SIG	standard deviation of F2-layer MUFS
SECD	secant(phi) at D height (100 KM)
DELF	take-off angle for this geometry (deg)
PSI	included angle from transmitter, earth center, receiver (deg)
PATHF	total slant range of path for this geometry (KM)

2.2.4.4 Subroutine XSLOSS

2.2.4.4.1 XSLOSS inputs

Call variables

GCD	great circle distance, transmitter to receiver (KM)

Common variables

CONNUM	number of control points in use

2.2.4.4.2 XSLOSS processing

Figure 5 illustrates the flow of subroutine XSLOSS. This routine compute the excess loss adjustment, ADJ.

Significant local variables are listed below:

ASM	median excess system loss

2.2.4.4.3 XLOSS outputs

ADJ	excess loss adjustment

2.2.4.5 Subroutine MODLOS

2.2.4.5.1 MODLOS inputs

Call variables

FREQ	current frequency (MHz)
DGYRO	gyro frequency at 100 KM (MHz)
ABSI	absorption index
HOPS	number of hops in this mode
PATH	slant range of this mode (KM)
SECD	secant(phi) at D height
DIST	distribution constant
LAYER	layer index, 1=E, 2=F
MUF	maximum usable frequency this layer (MHz)
FO	critical frequency (MHz) - not currently referenced
SECPHE	secant(phi) - not currently referenced
ADJ	excess system loss adjustment from XSLOSS (dB)

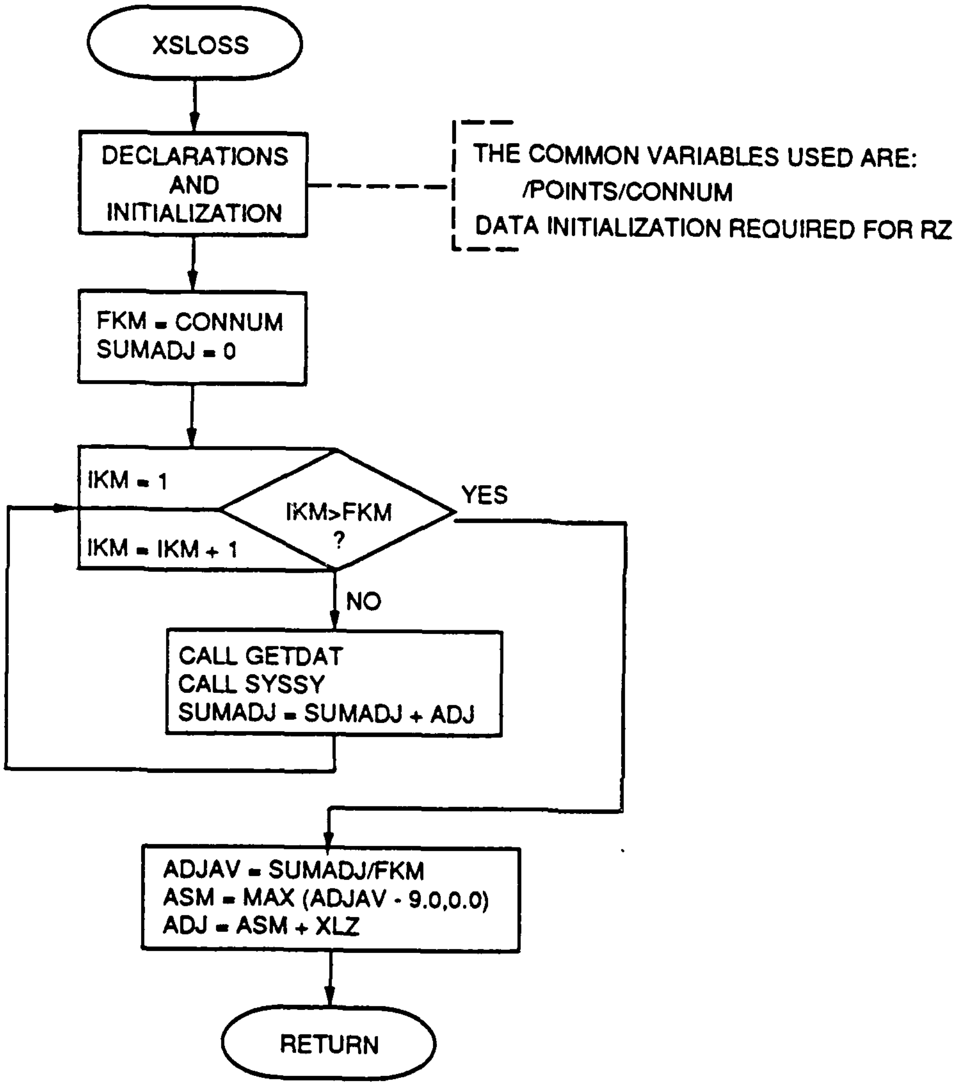


Figure 5. Subroutine XSLOSS

2.2.4.5.2 MODLOS processing

Figure 6 illustrates the flow of subroutine MODLOS. This routine computes transmission losses, TLOSS.

Significant local variables are listed below:

GZ	Ground loss
FSLOSS	Free space loss
ABPS	deviative absorption
XLS	additional loss due to propagation at frequency > MUF

2.2.4.5.3 MODLOS outputs

TLOSS	transmission losses (dB)

2.2.4.6 Subroutine GEOHOP

2.2.4.6.1 GEOHOP inputs

Call variables

HOPS	the number of hops for which geometry is determined
GCD	great circle distance (radians)
HEIGHT	height of layer for this mode (KM)

2.2.4.6.2 GEOHOP processing

Figure 7 illustrates the flow of subroutine GEOHOP. The purpose of this routine is to compute the values of the angles and distances associated with the geometry of a hop.

2.2.4.6.3 GEOHOP outputs

SECPHE	secant(phi) at current layer height
DEL	take-off angle for this geometry (deg)
PATH	total slant range for this geometry (KM)
PSI	included angle for half hop, radians from earth center (deg)
SECD	secant(phi) at D-layer (100 KM) height (deg)

2.2.4.7 Function AINDEX

2.2.4.7.1 AINDEX inputs

Call variables

CHI	solar zenith angle (deg)
SSN	sunspot number (Zurich running average)

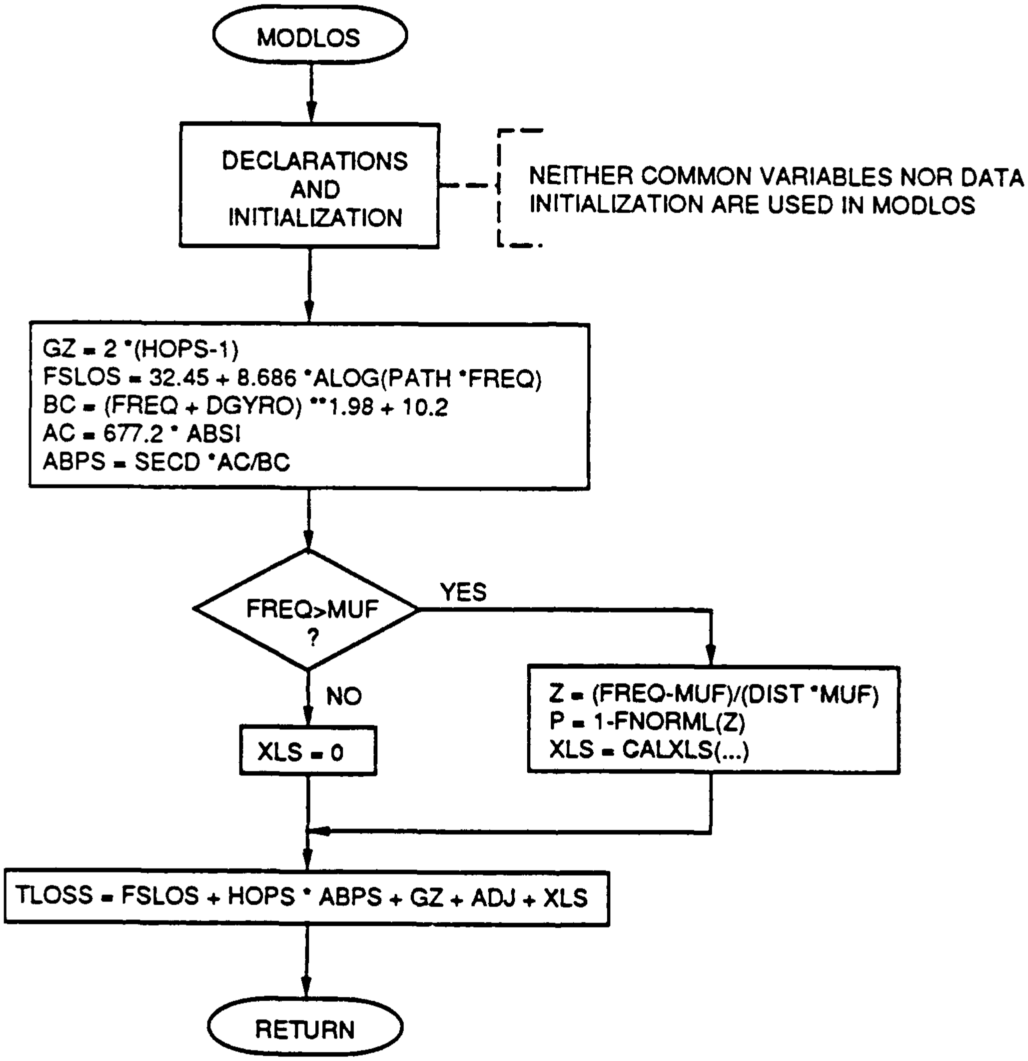


Figure 6. Subroutine MODLOS

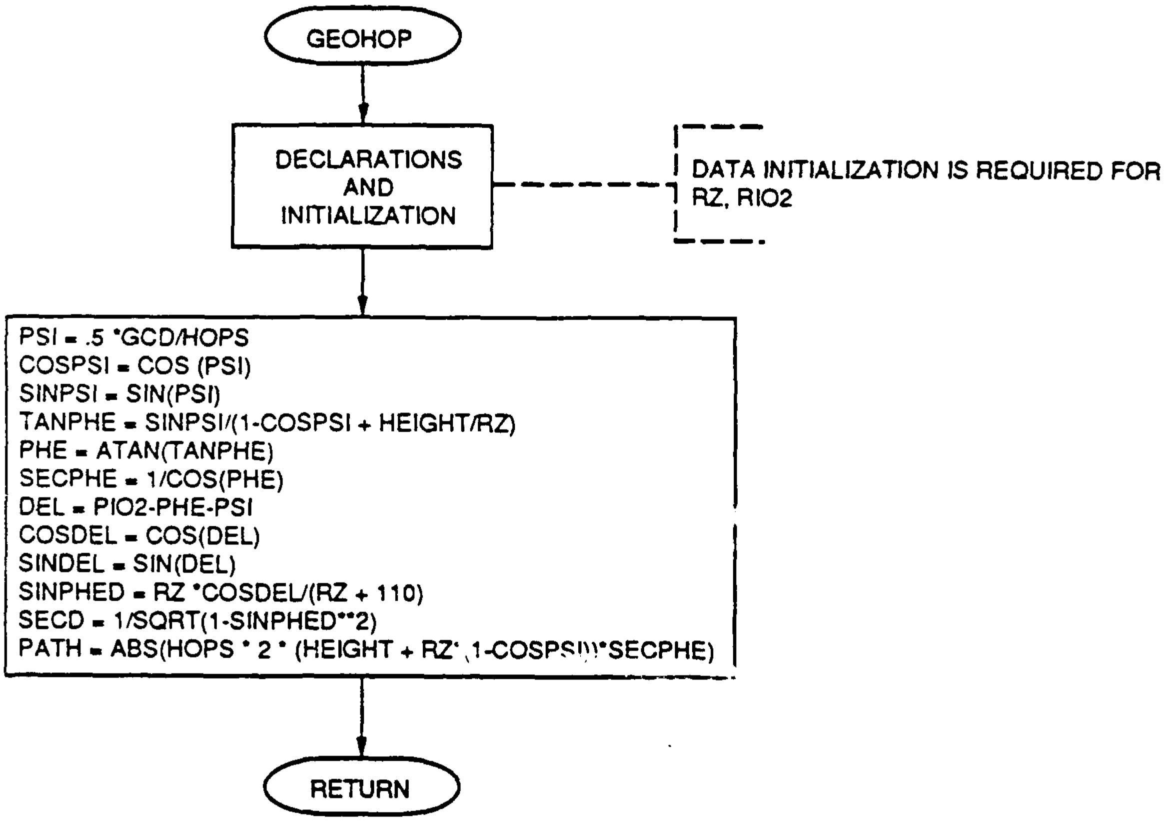


Figure 7. Subroutine GEOHOP

2.2.4.7.2 AINDEX processing

Figure 8 illustrates the flow of function AINDEX. This function computes the value of the absorption index, AINDEX.

2.2.4.7.3 AINDEX outputs

AINDEX	absorption index

2.2.4.8 Subroutine SYSSY

2.2.4.8.1 SYSSY inputs

Call variables

GLAT	geomagnetic latitude of reflection area (deg N & S)
Z	reflection area local mean time (hours: 0-23)
GCDRAD	great circle distance (radians)

Common variables

R2D	factor for converting radians to degrees

2.2.4.8.2 SYSSY processing

Figure 9 illustrates the flow of subroutine SYSSY. This routine computes the excess system loss, FM.

2.2.4.8.3 SYSSY outputs

FM excess system loss (dB)

2.2.4.9 Subroutine F2DIS

2.2.4.9.1 F2DIS inputs

Call variables

FMUF	F2MUF (MHz)
SSN	sunspot number (Zurich running average)
CLAT	geographic latitude (deg N & S)
FREQ	operating frequency (MHz)
AB	local mean time (hours: 0-23)
MONTH	current month

2.2.4.9.2 F2DIS processing

Figure 10 illustrates the flow of subroutine F2DIS. This routine computes the standard deviation of the normal F2MUF.

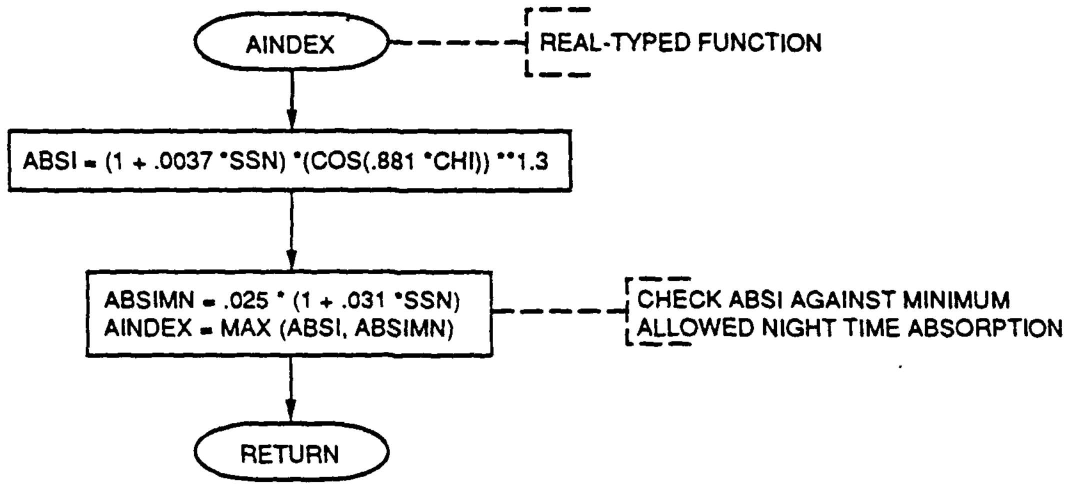


Figure 8. Function AINDEX

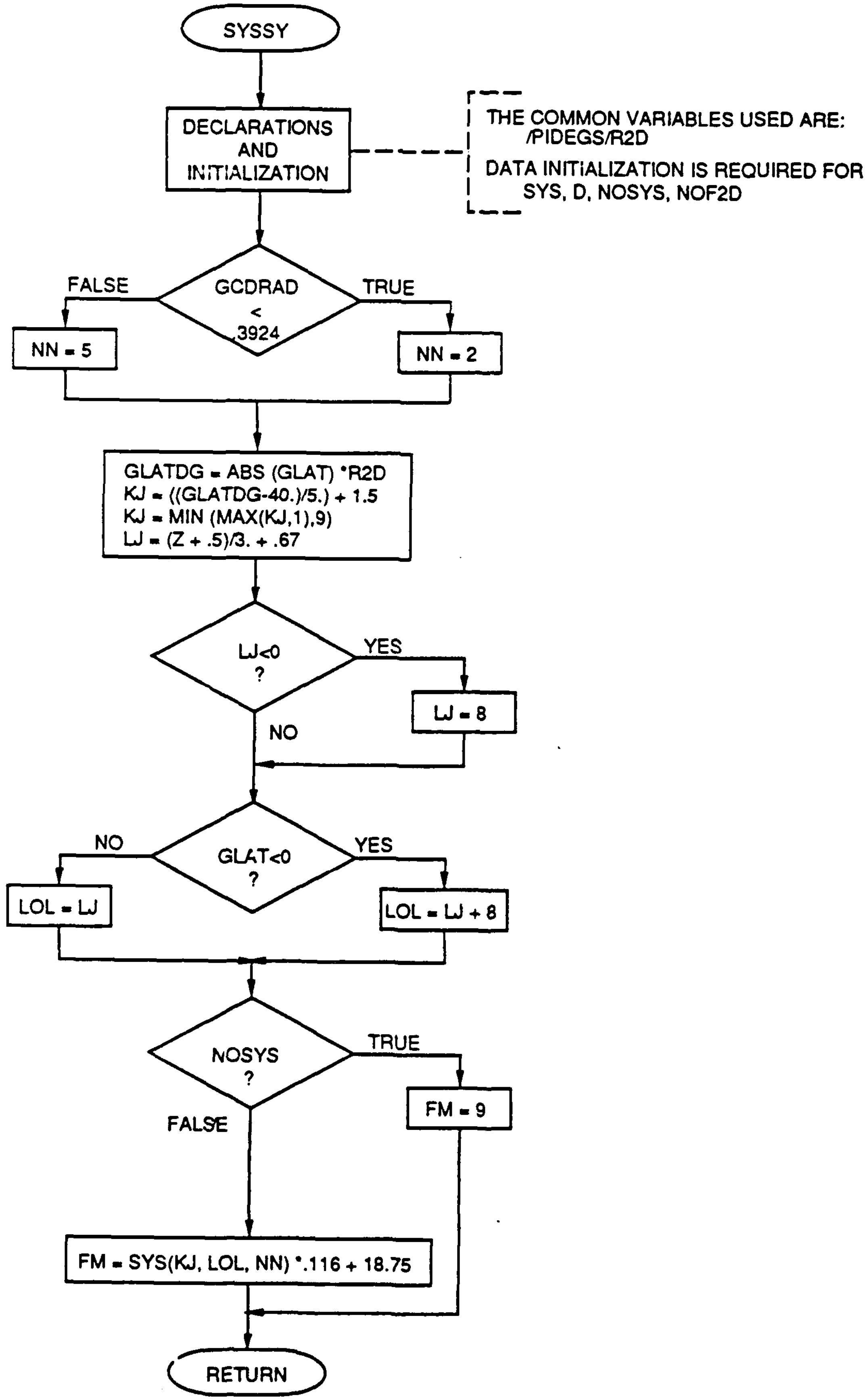


Figure 9. Subroutine SYSSY

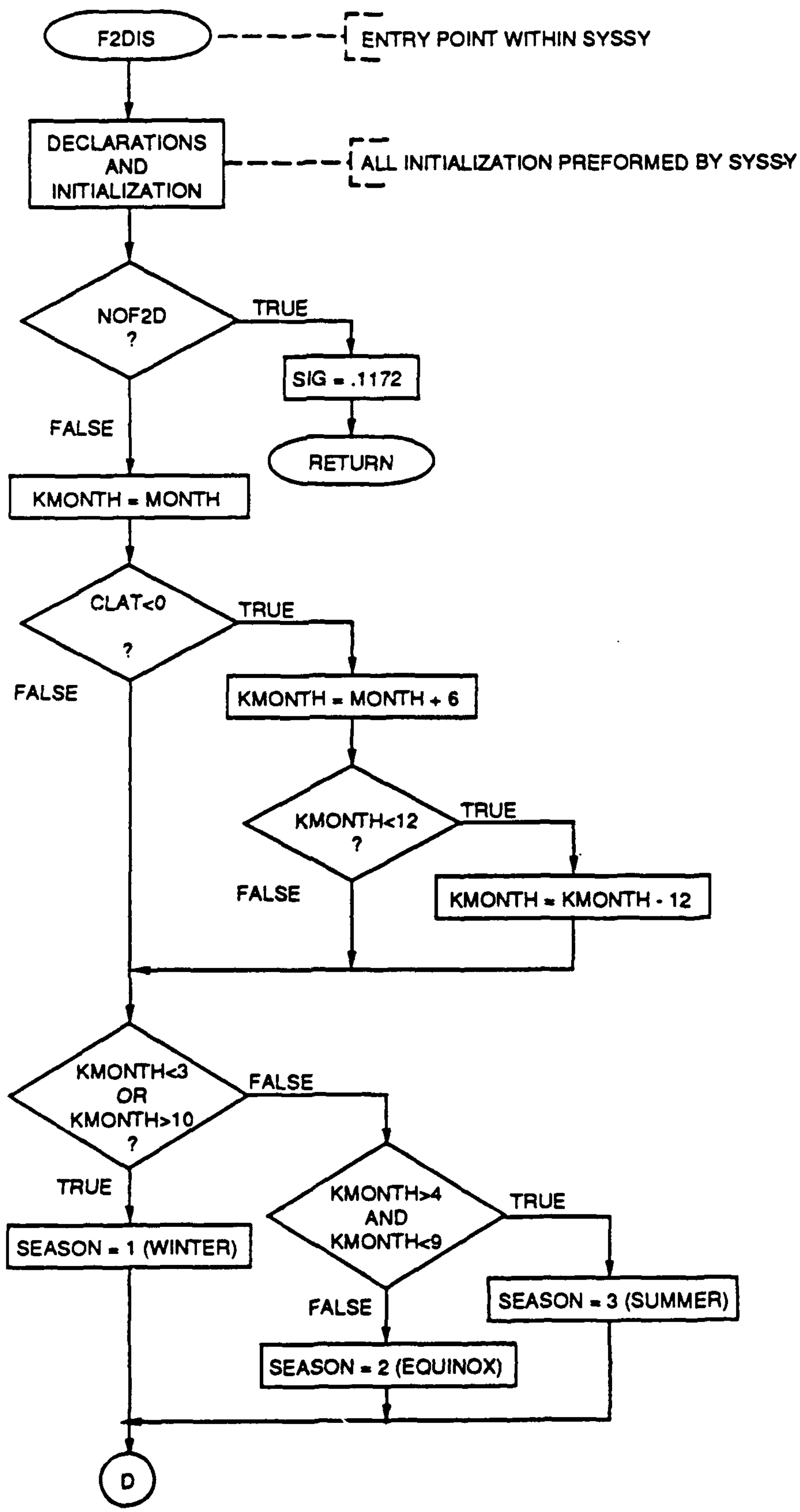


Figure 10. Subroutine F2DIS (Sheet 1 of 4)

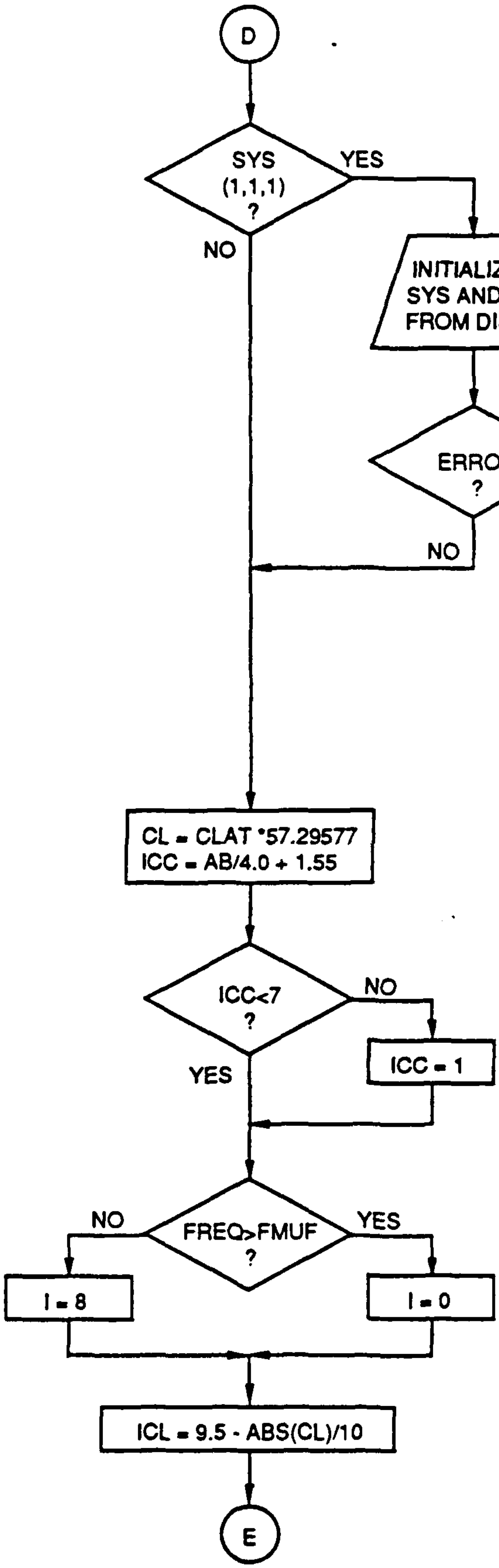


Figure 10. Subroutine F2DIS (Sheet 2 of 4)

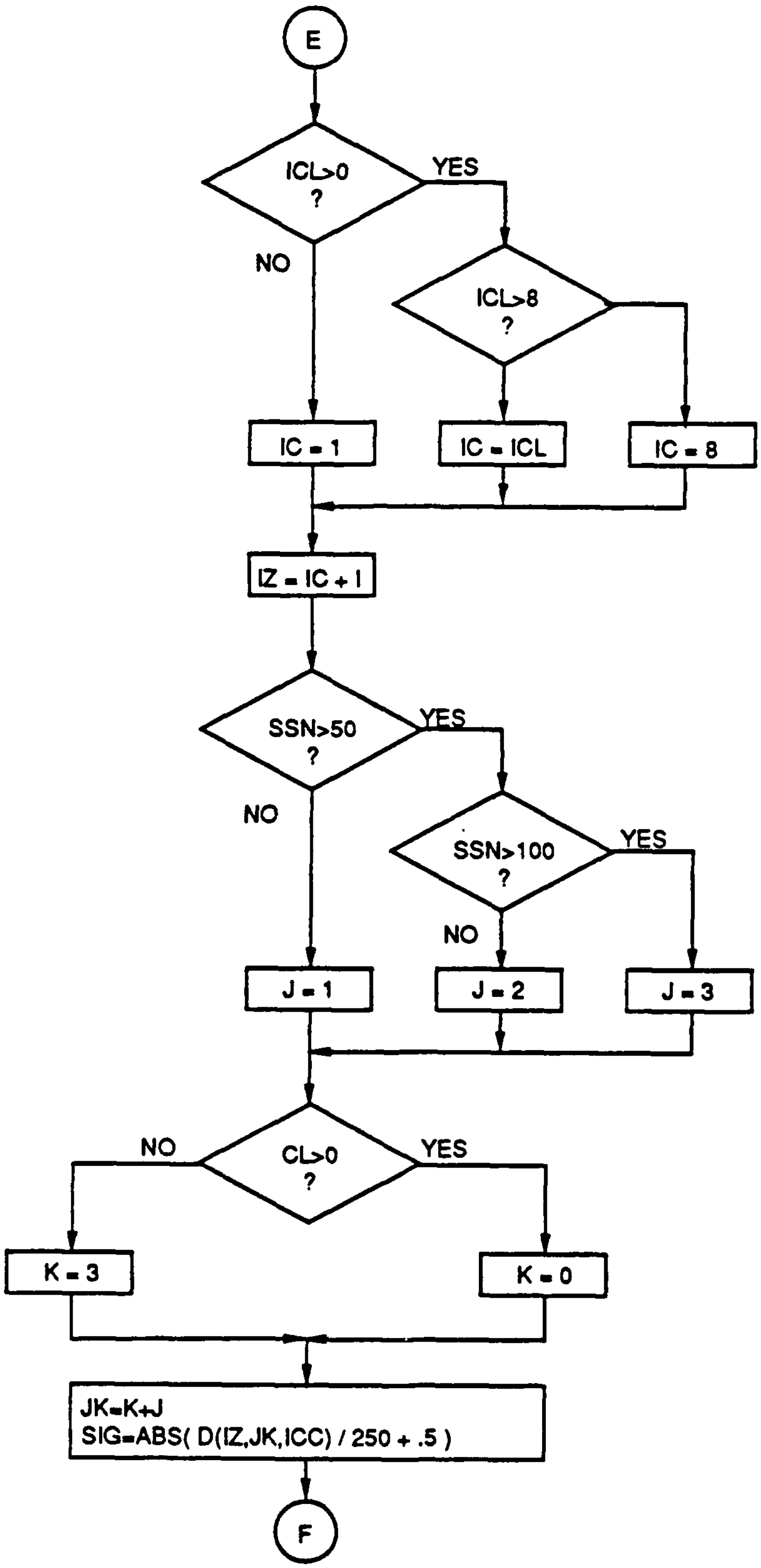


Figure 10. Subroutine F2DIS (Sheet 3 of 4)

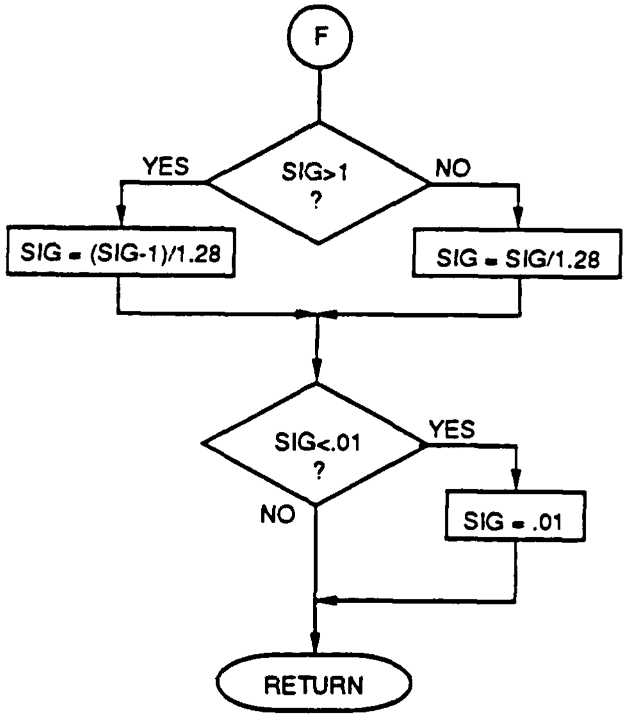


Figure 10. Subroutine F2DIS (Sheet 4 of 4)

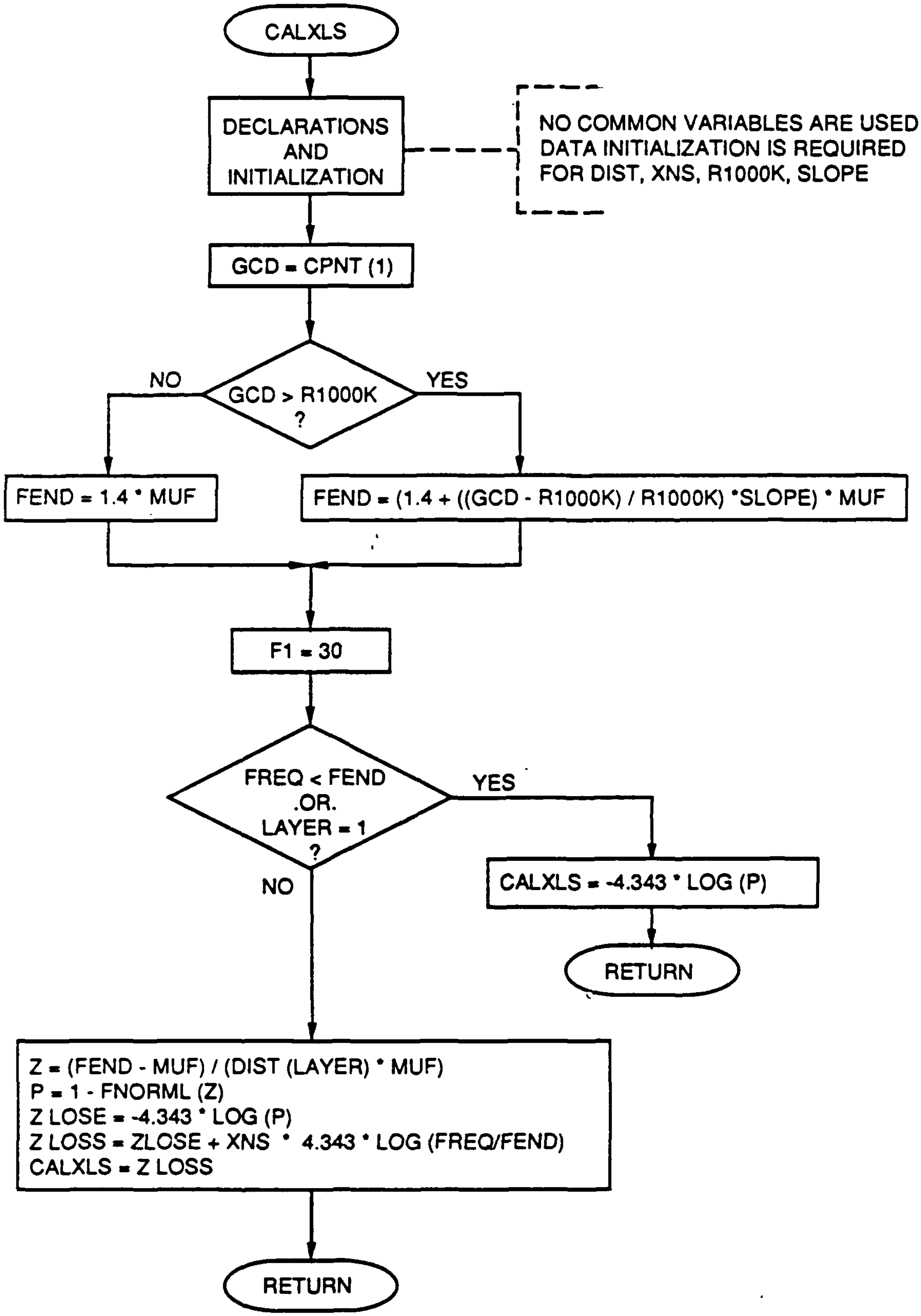


Figure 11. Function CALXLS

2.2.4.11 Subroutine GETDAT

2.2.4.11.1 GETDAT inputs

Call variables

IKM	control point index (1=first, 2=second, etc.)

Common variables

CONLAT	array of control point geographic latitudes (deg N & S)
CONLON	array of control point geographic longitudes (deg E & W)
CONLMT	array of control point local mean times (hours: 0:23)
CONMLAT	geomagnetic latitudes of control points in CPMT (deg N & S)

2.2.4.11.2 GETDAT processing

Figure 12 illustrates the flow of subroutine GETDAT. This is routine translates variable names and formats of data for compatibility with the rest of the field stength module.

2.2.4.11.3 GETDAT outputs

LO	geographic longitude of control point IKM (deg E & W)
WO	geographic latitude of control point IKM (deg N & S)
LMTNOW	local mean time of control point IKM (hours: 0-23)
MLAT	geomagnetic latitude of control point IKM (deg N & S)
CHI	solar zenith angle of control point IKM (deg)

2.2.4.12 Function ZENANG

2.2.4.12.1 ZENANG inputs

Call variables

LO	geographic longitude (deg E & W)
WO	geographic latitude (deg N & S)

COMMON variables

SLAT	subsolar latitude (deg N & S)
SLON	subsolar longitude (deg E & W)

2.2.4.12.2 ZENANG processing

Figure 13 illustrates the flow of function ZENANG. This function computes the zenith angle, ZENANG.

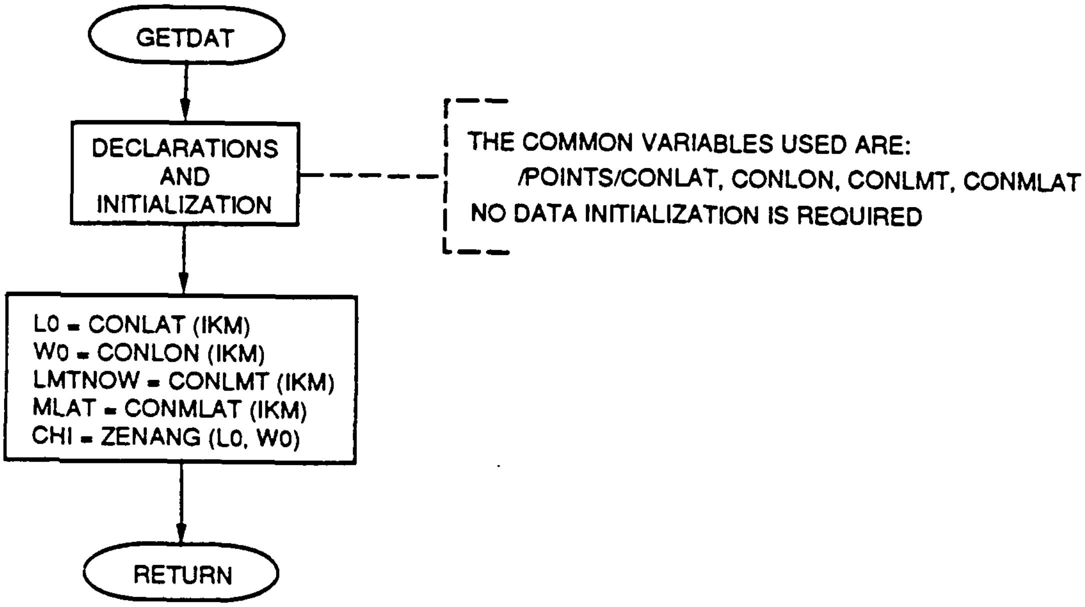


Figure 12. Subroutine GETDAT

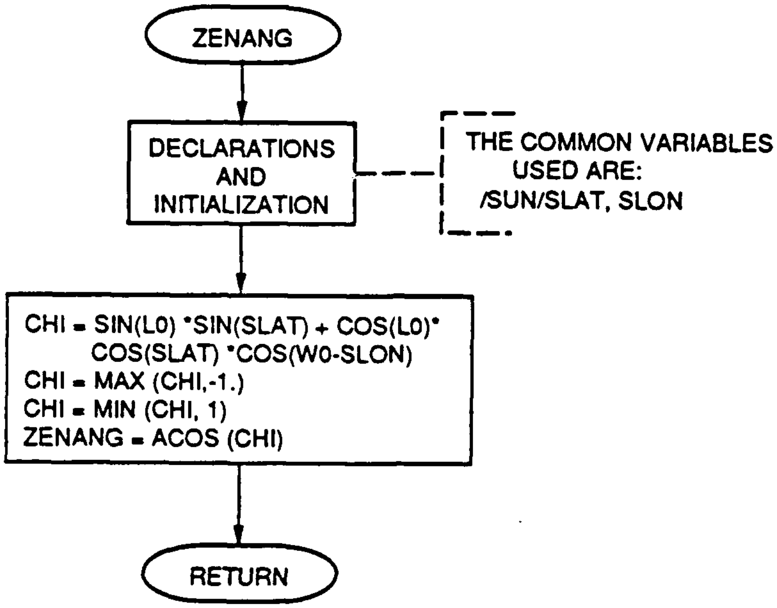


Figure 13. Function ZENANG

2.2.4.12.3 ZENANG outputs

ZENANG zenith angle (deg N & S)

2.2.4.13 Function FNORMAL

2.2.4.13.1 FNORMAL inputs

Y number of standard deviations from distribution center

2.2.4.13.2 FNORMAL processing

Figure 14 illustrates the flow of function FNORMAL. This function computes the cumulative normal distribution, FNORMAL, from a maximum of 5 standard deviations.

Significant local variables are described below:

Y number of srtandard deviations above the mean
S cumulative normal distribution from the mean

2.2.4.13.3 FNORMAL outputs

Y number of standard deviations from distribution center
FNORMAL cumulative normal distribution (from maximum of 5 standard deviations)

2.2.5 References

1. D.L. Lucas and G.W. Haydon, "Predicting the Statistical Performance Indexes for High Frequency Ionospheric Telecommunication Systems," ESSA Technical Report IER-1-(ITSA-1), Aug 1966.

2. NOSC TR 1121, MINIMUF-85: An Improved HF MUF Prediction Algorithm, D.B. Sailors, R.A. Sprague and W.H. Rix, July 1986.

3. J.L. Lloyd and D.L. Lucas (Authors with ITS/NTIA, Boulder, Co), Estimating the Performance of Telecommunication Systems using the Ionospheric Transmission Channel (IONCAP) (Report of Work Performed for US ARMY), U.S. Army Electromagnetic Office, Propagation Engineering Division, Technical Report, EMEO-PED-79-7, Sep 1978.

4. Headrick and Lucas, et al, Virtual Path Tracing for HF Radar Including an Ionospheric Model, NRL Report 222L, Mar 1971.

5. JTAC Report on Scatter Propagation, Joint Technical Advisory Committee, 1960.

6. JTAC, Radio Spectrum Utilization, Joint Technical Advisory Committee, 1964.

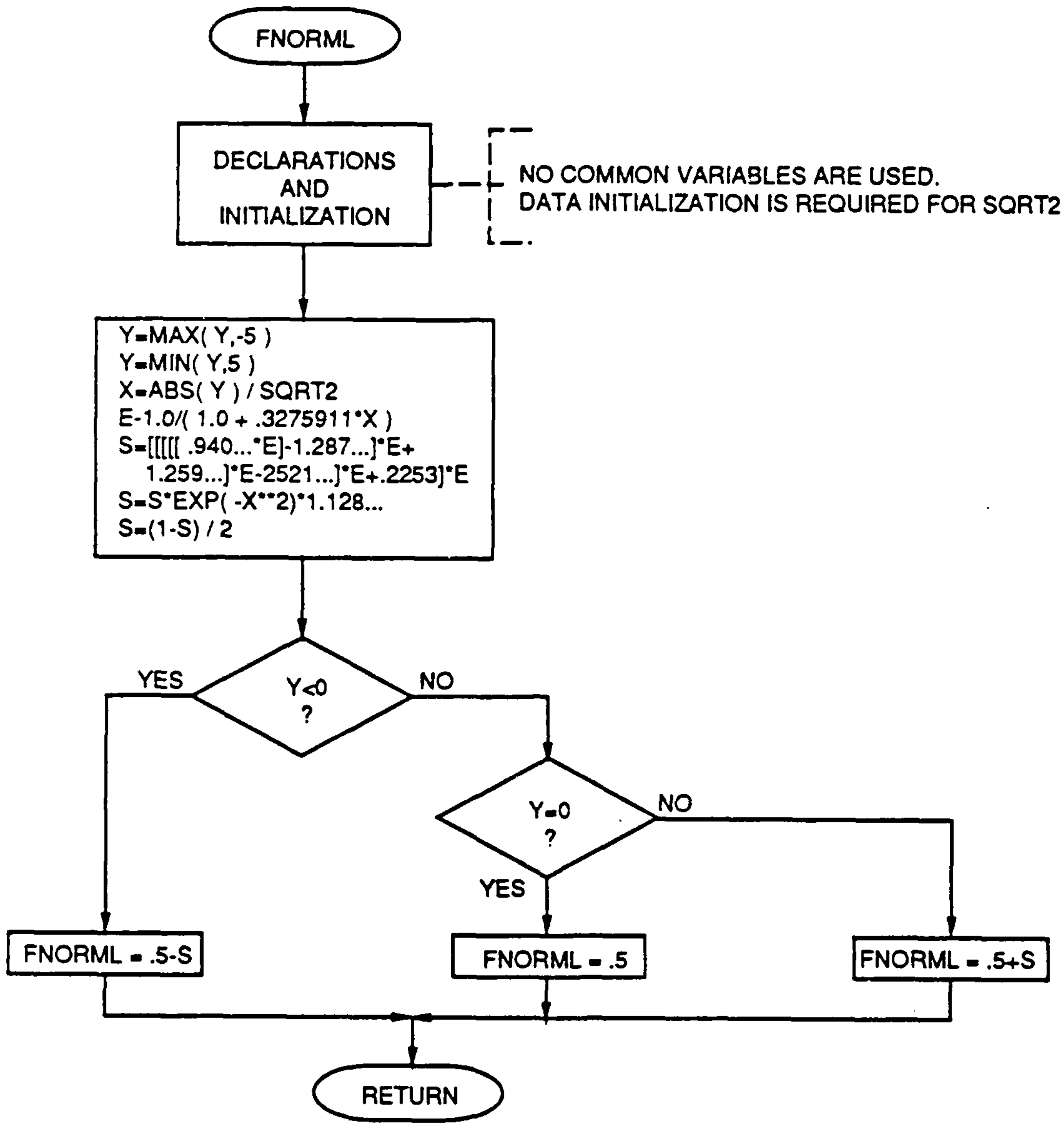


Figure 14. Function FNORML

7. N. Wakai, Ray Paths and Absorption of MF and HF Radio Waves Incident on the Ionosphere, Journal of Radio Research Labs, May 1971.

8. T. Damboldt and P. Sussman, Extending Field Strength Predicitons (for short distances) to Frequencies Above the Standard MUF, CCIR IWP 6/1, Doc 45, Mar 1976.

9. K. A. Norton, Transmission Loss in Radio Propagation, NBS, Tech Report Note 12, Jun 1959.

2.3 SOUNDER UPDATE (SU)

2.3.1 Scope

2.3.1.1 Identification

SUBROUTINE SOUNDR

Callable through the existing module REal-time (GETRTM) by first entering command "RE" through the main line "TDA" program, and then responding 'Y' to the question "DO YOU WANT REAL TIME DATA"; or by the new, direct command "SU" enterable through the main line "TDA" program.

2.3.1.2 Programmer

D. J. Brandon -- Systems Exploration, Inc.

2.3.1.3 Purpose

The sounder update module allows the user to calculate a 'local' pseudo Sun Spot Number (SSN) and pseudo flux value, based on the location of a user-defined transmitting and receiving antenna, and a reference sounder path MOF, which is then used to derive a more accurate MUF prediction for other paths.

2.3.1.4 Background

The computer model development for Sounder Updates in this system is a re-hosted version of the BASIC model operating on the Tektronix 4052 Graphics System for the Army Prophet Evaluation System (APES).

Reference to external routines were modified to match those used in the TDA operating environment, where a similiar function already existed. New subroutine CVTLL was written to handle the numeric conversions required to list out the site latitudes and longitudes as that function was not readily available in the existing TDA subroutine library.

2.3.1.5 Restrictions and Limitations

The sounder update module is built around the MUF85 model, with a MOF range between 2 and 50 which is consistent with other models operating within the TDA environment.

The new model was enhanced to solve for the computed MUF value to three decimal points, increase SSN range up to a value of 250, and be able to converge on the proper MUF values from either direction.

2.3.1.6 Language

HP FORTRAN/77

2.3.1.7 Computer Configuration

HP 9000 Series 500 HP-UX (HP 9050)

2.3.1.8 Models Referenced

AS, DA, RE, SS, TDA, TM

2.3.2 Numeric Method

The SORFMS program will be able to use information obtained from an HF oblique sounder to update the value of 10.7 cm flux used in the MINIMUF model. To take advantage of this feature, a sounder path must be defined and the maximum observed freqeuncy (MOF) from the sounder must be updated periodically. The user enters receiver and transmitter parameters associated with the sounder site including latitude, longitude, antenna, power, and antenna orientation. Once these parameters are established for a given sounder path, the user may skip this step. The user enters the current MOF for the sounder path. The system then will compute a value of 10.7-cm flux that will cause the computed MUF for the sounder path to agree with the MOF. This value of 10.7-cm flux will then be used for all MUF calculations until it is changed by another SU command, or until a different value is specified by the FL (flux) command. To provide this sounder update capability in SORFMS, the Sounder Update module was rehosted from APES.

2.3.3 Module Design Description

2.3.3.1 Required Input

a. User entries to initiate the Sounder Update model:

1. Date of the sounder MOF specified stored in variables MONTH, DAY, JDAY, YEAR. (Set by the TDA command 'DA'.)

2. Time of the sounder MOF specified stored in variables HOUR and MINUTE. (Set by the TDA command 'TI'.)

3. Sun Spot Number (SSN) of the sounder MOF specified stored in variable (TBS). (Set by the TDA command 'SS'.)

4. Transmitter site, including the site latitude (STALAT(KXMT)) and longitude (STALON(KXMT)). (These values may be set up by the TDA command 'AS', but only the site Name may be entered within the Sounder module.)

5. Receiver site, including the site latitude (STALAT(KRCV)) and longitude (STALON(KRCV). (These values may be set up by the TDA command 'AS', but only the site Name may be entered within the Sounder module.)

6. Sounder MOF on this path (CMUF).

b. Subroutine SOUNDR Inputs

No called variables

COMMON Variables:

LUNI	CRT input logical unit (5)
LUNO	CRT output logical unit (6)
MNEM	Array of three-character months of the year
DTR	Conversion factor for degrees-to-radians
LISTA1	Primary array of input characters received from user
LISTB1	Secondary array of input characters received from user
MONTH	Month of model run
DAY	Day of model run
MINUTE	Minute of model run
NUMSTA	Number of stations (sites) available in TDA environment
STAANT	Array of antenna number (type) for all sites
FLX10	10.7 cm flux
SSN	Sun spot number
STALAT	Array of latitudes for all sites
STALON	Array of longitudes for all sites
STABRG	Array of bearings for all sites
STAPWR	Array of powers for all sites

2.3.3.2 Processing

Figures 15 and 16 illustrate the flow of the SU module. Once the model system is initialized, the user is prompted to enter the transmitter and receiver sites to define the path in question. He is then prompted to enter the sounder MOF of the specified path. These values, along with the system date, time and SSN are then used to convert the supplied MOF to the MUF value of this instant.

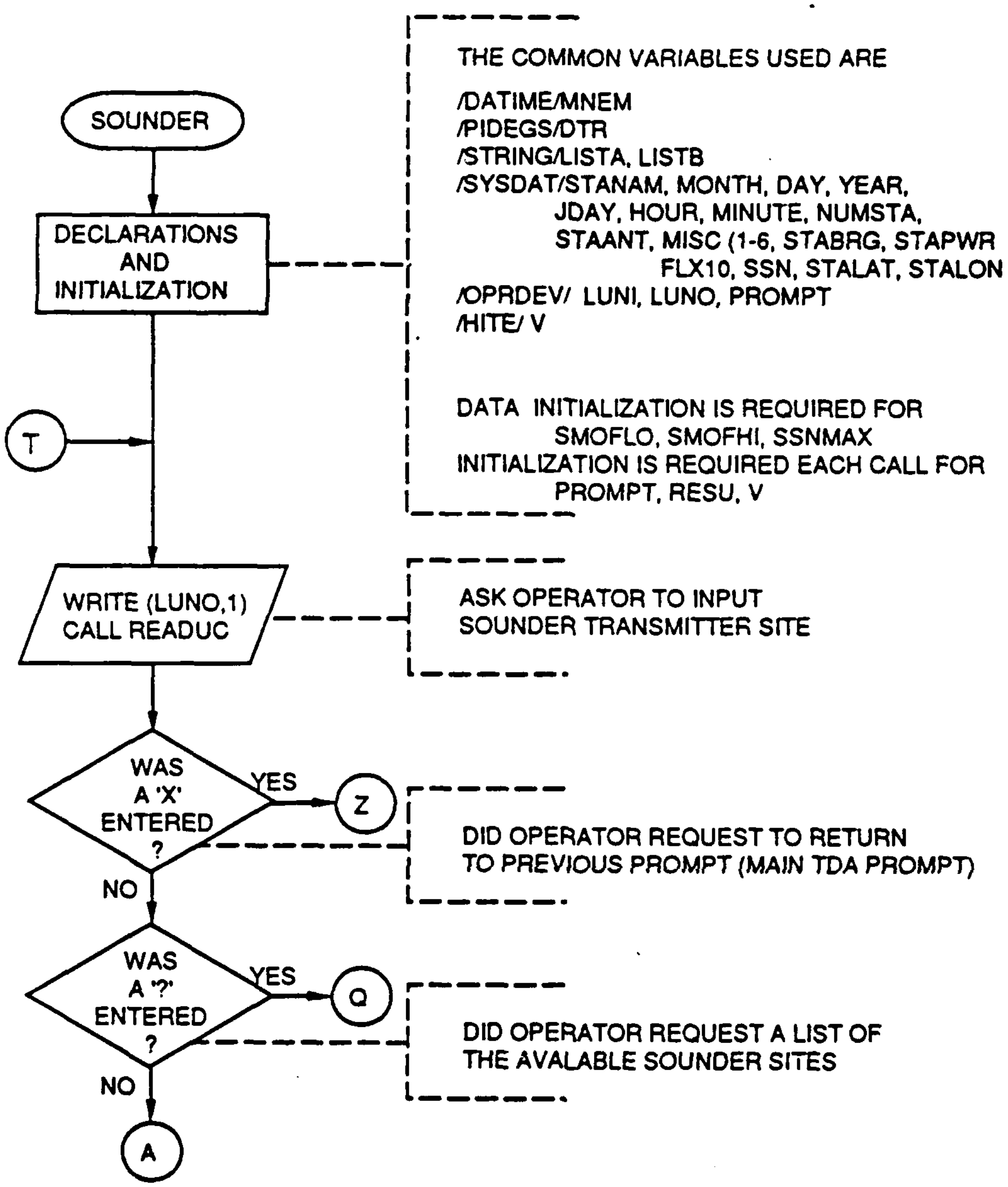


Figure 15. Subroutine SOUNDR (Sheet 1 of 9)

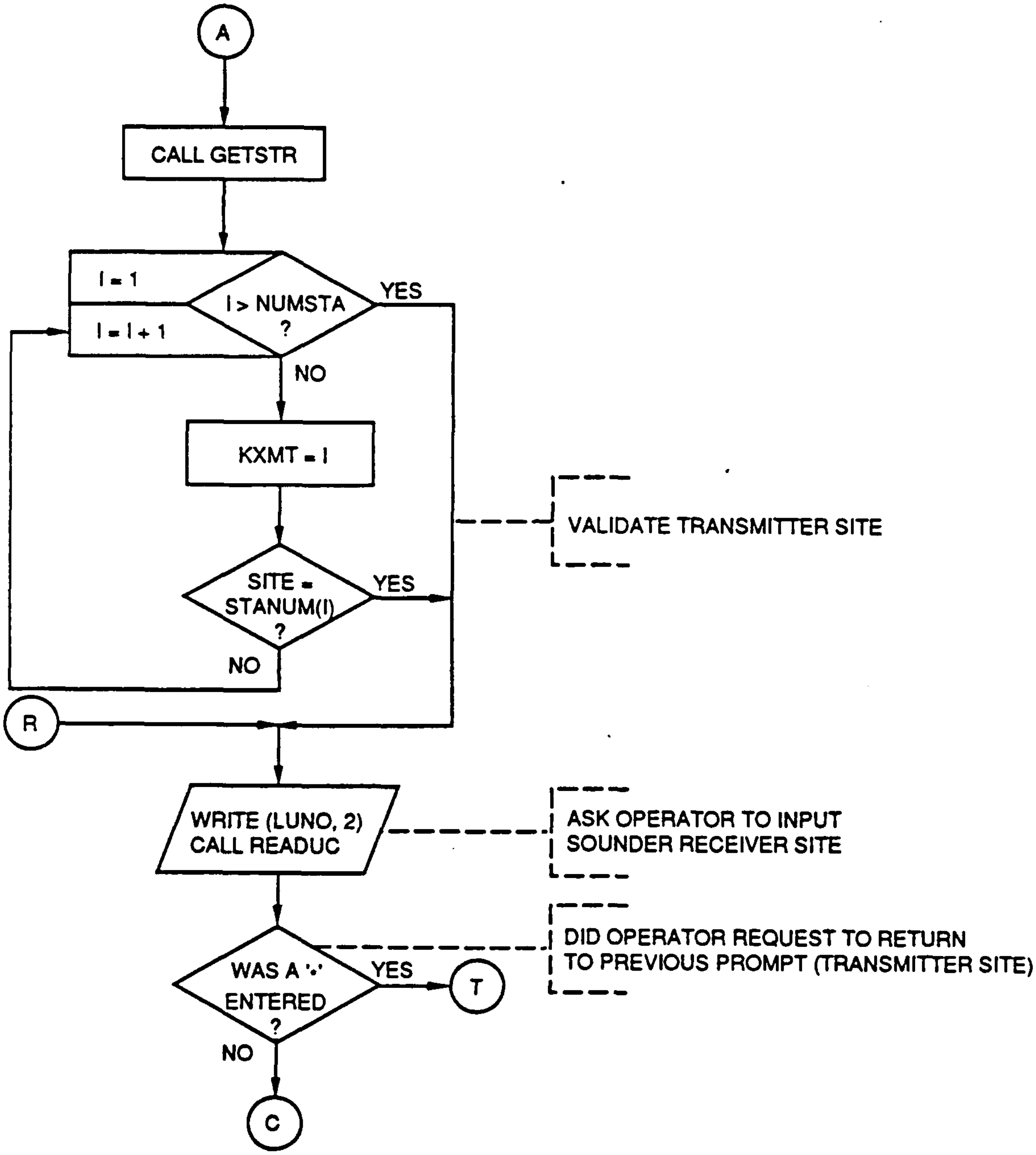


Figure 15. Subroutine SOUNDR (Sheet 2 of 9)

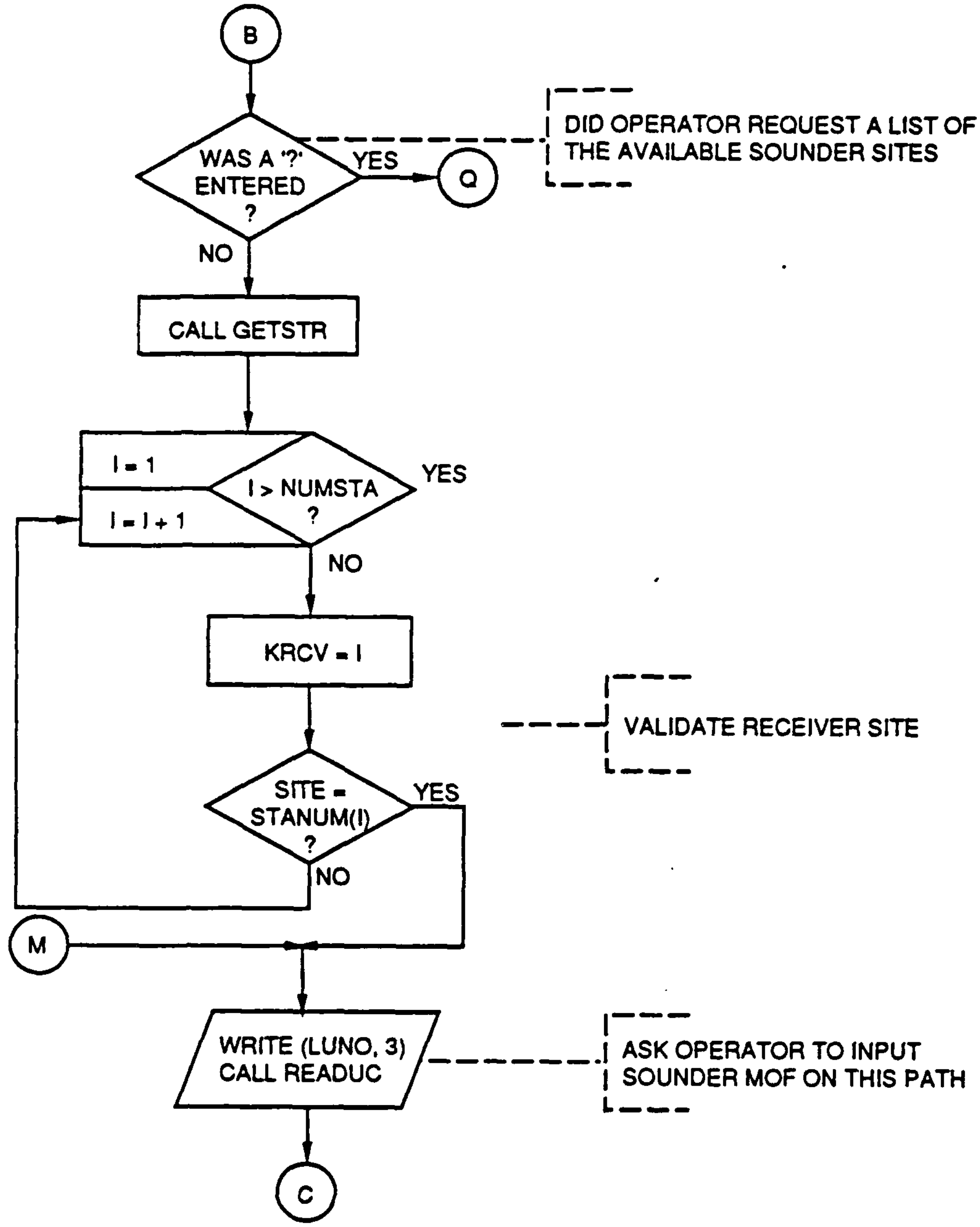


Figure 15. Subroutine SOUNDR (Sheet 3 of 9)

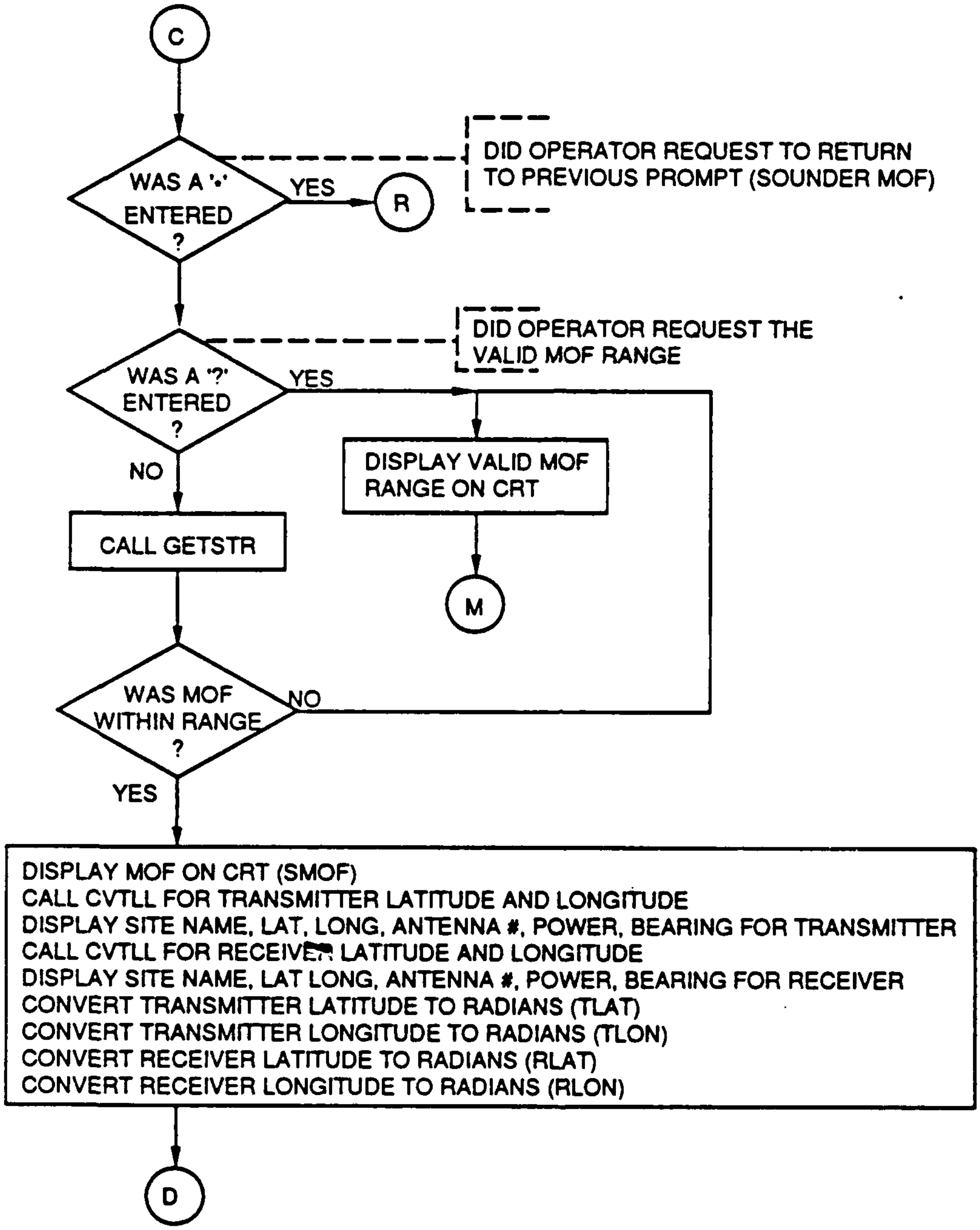


Figure 15. Subroutine SOUNDR (Sheet 4 of 9)

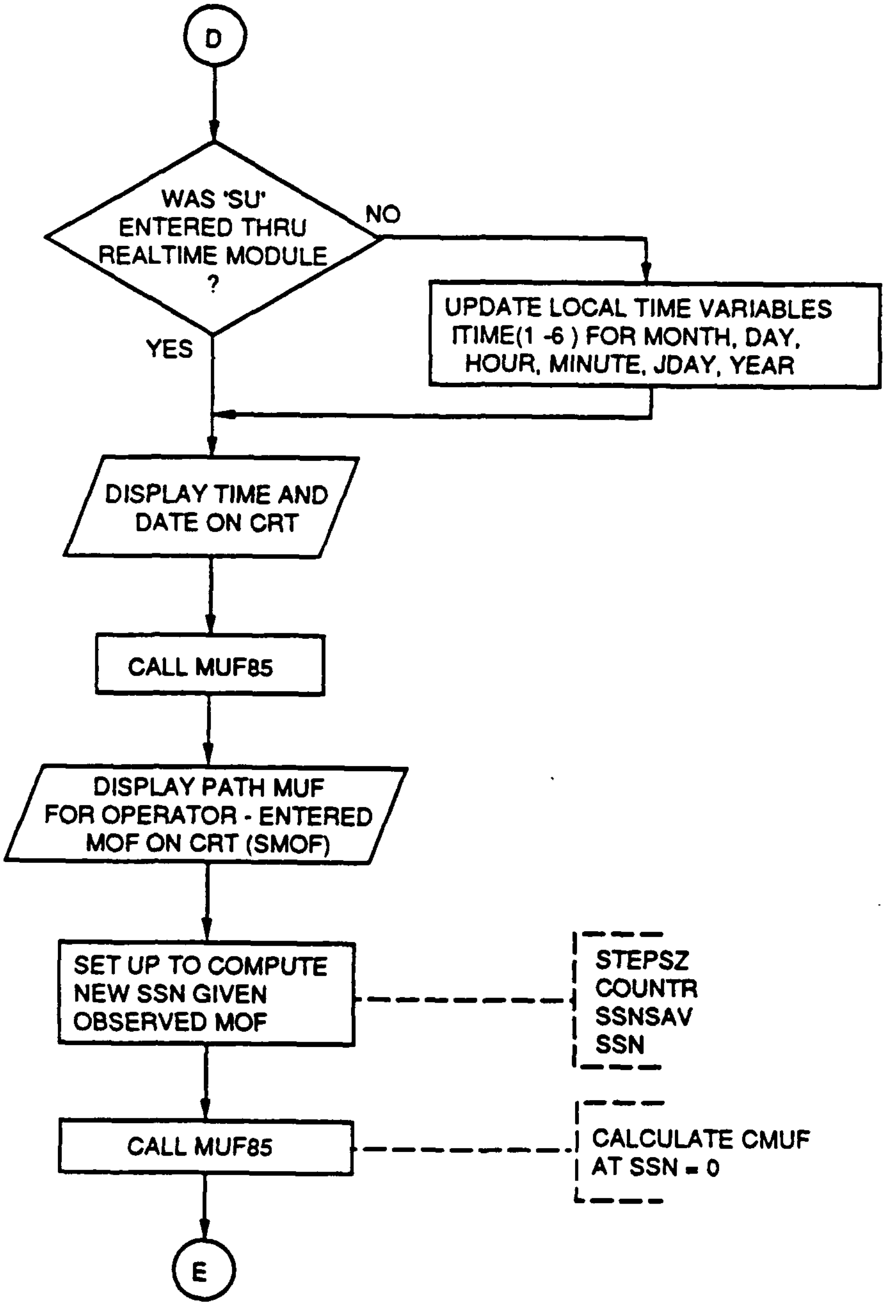


Figure 15. Subroutine SOUNDR (Sheet 5 of 9)

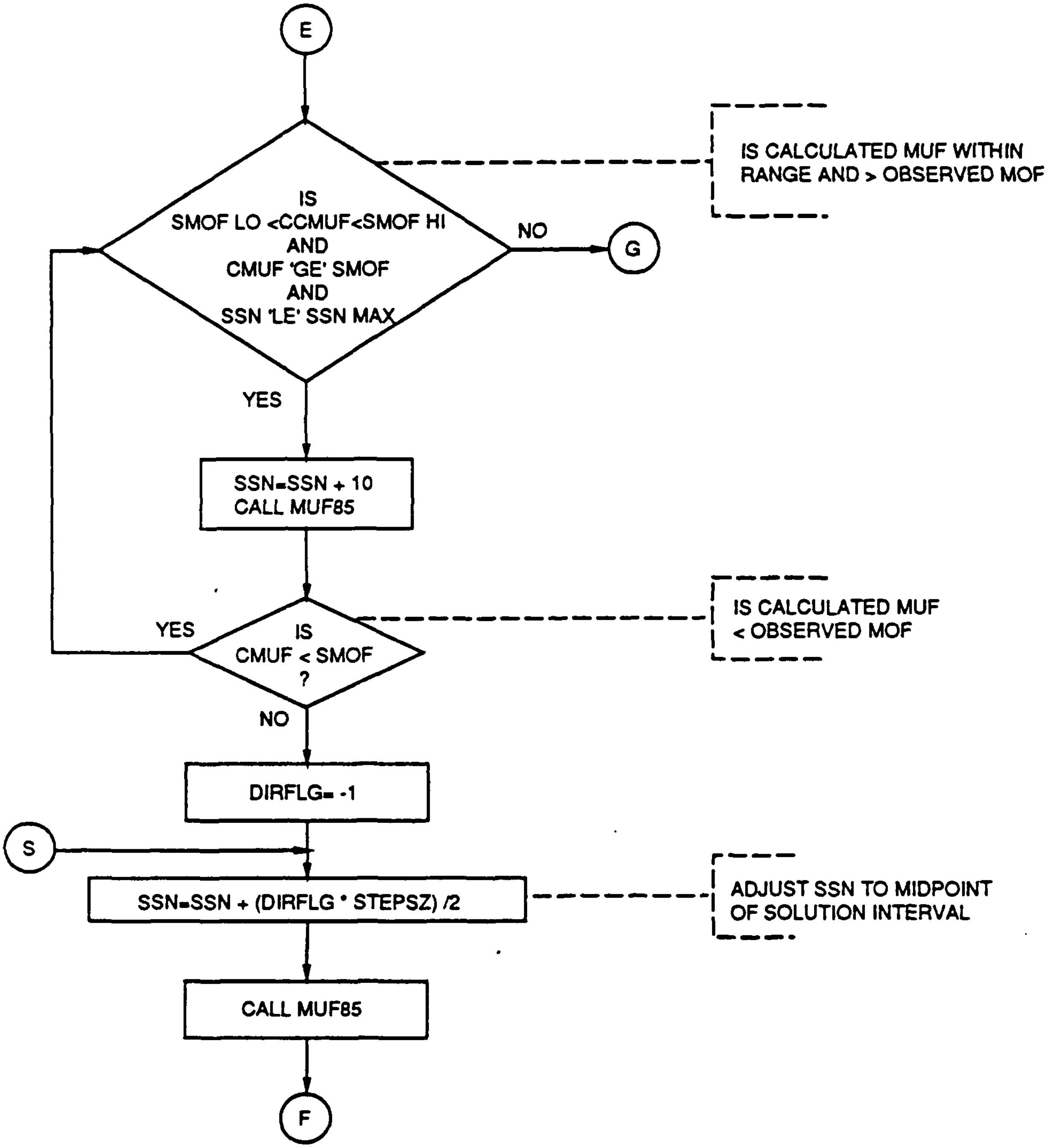


Figure 15. Subroutine SOUNDR (Sheet 6 of 9)

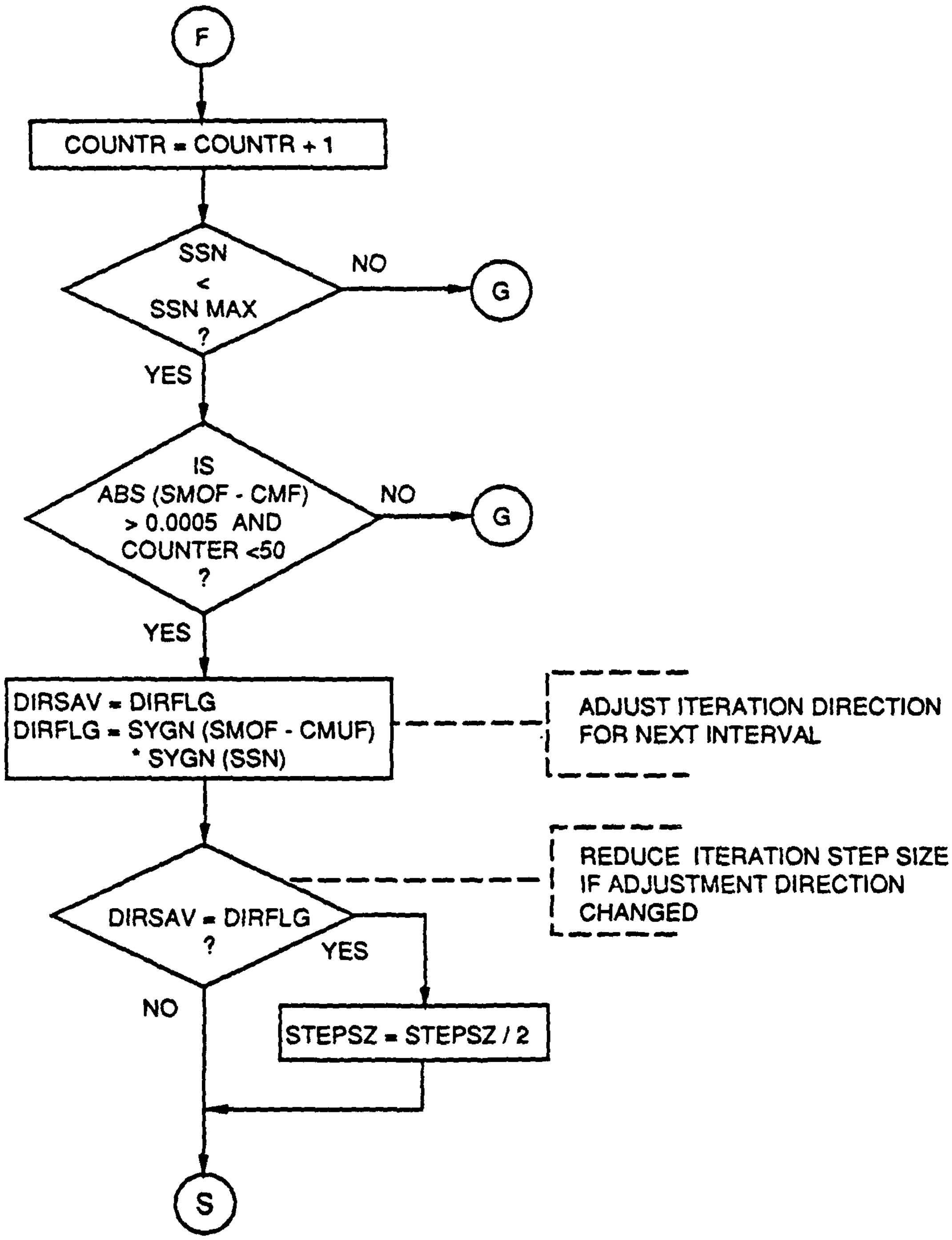


Figure 15. Subroutine SOUNDR (Sheet 7 of 9)

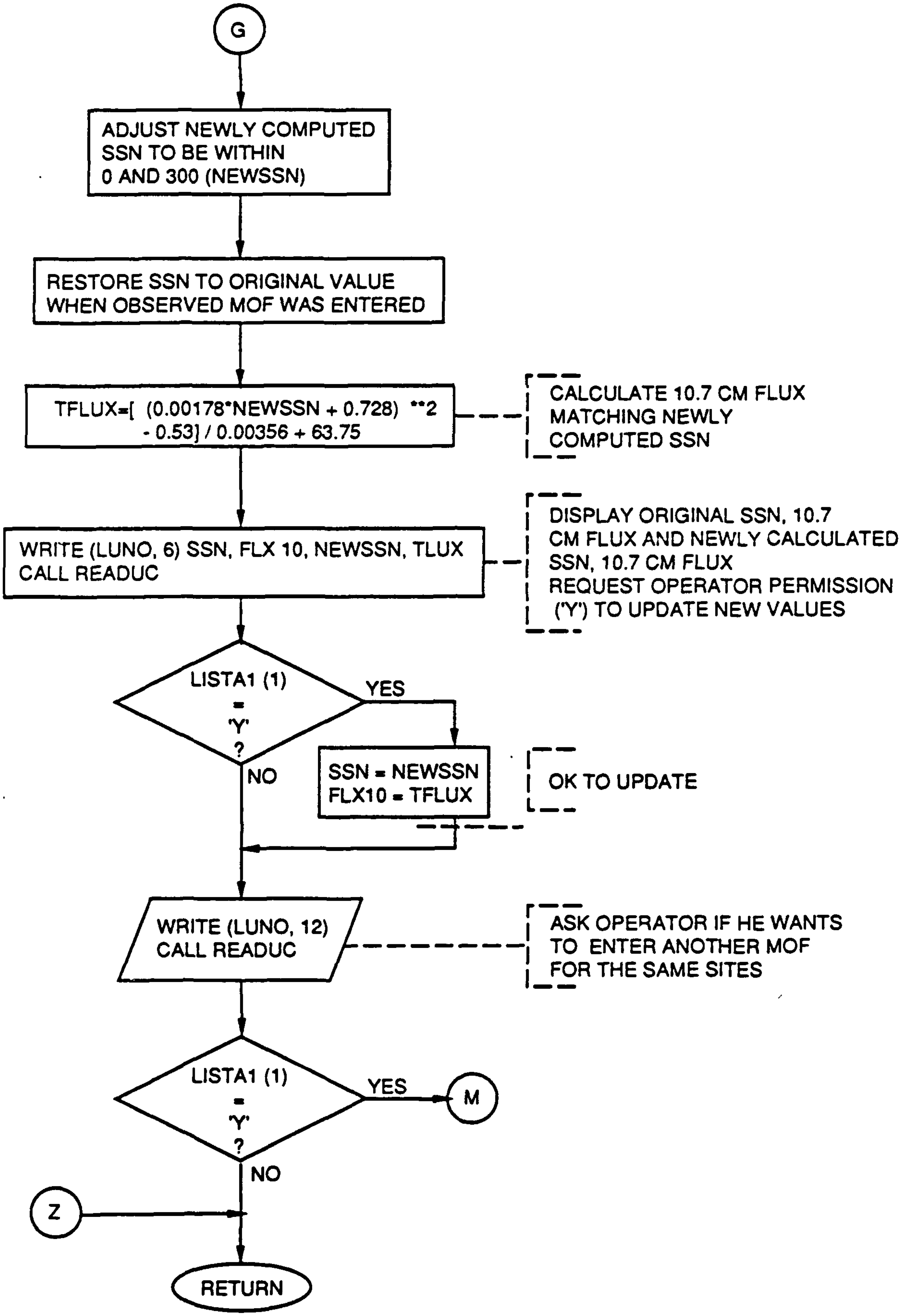


Figure 15. Subroutine SOUNDR (Sheet 8 of 9)

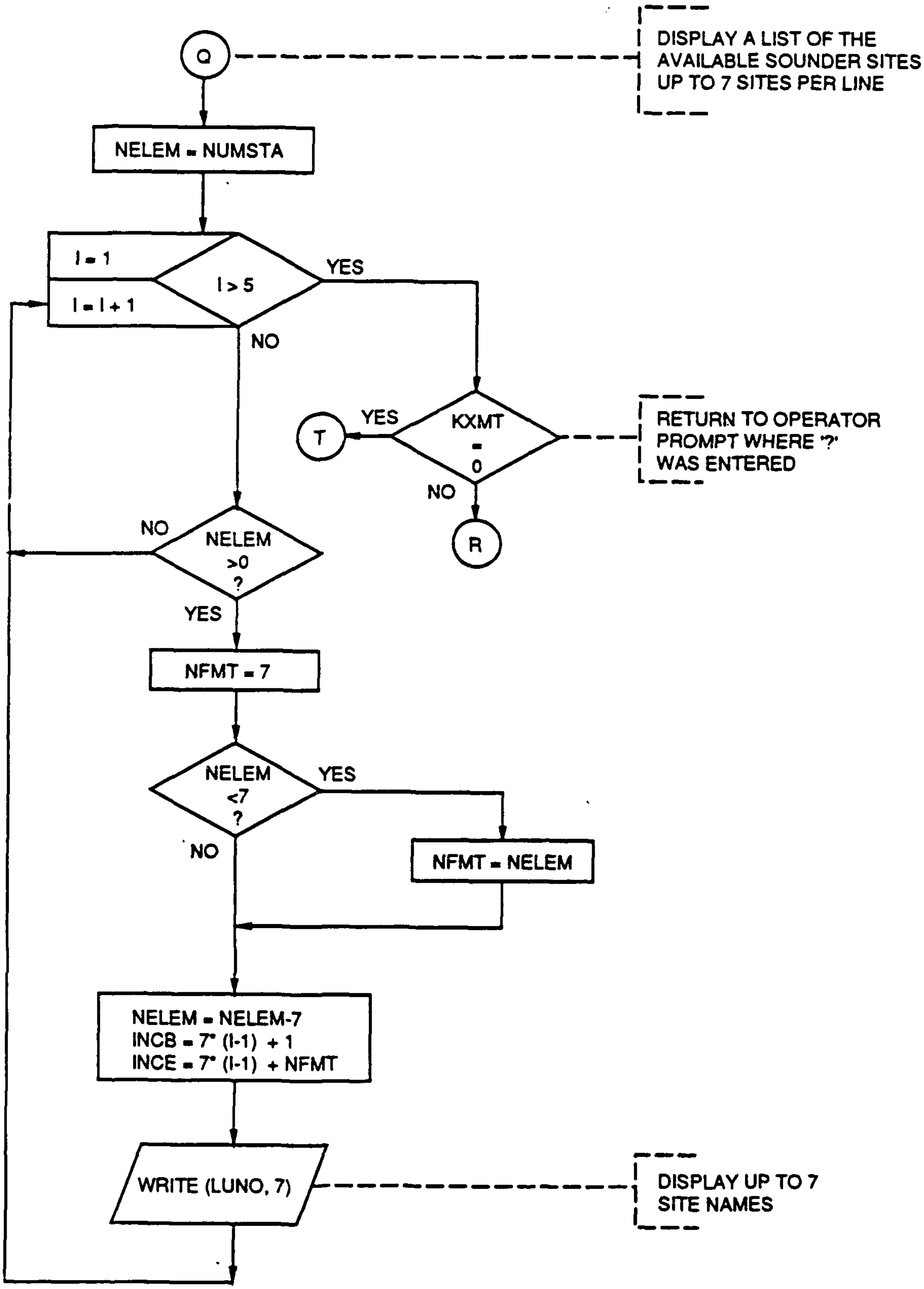


Figure 15. Subroutine SOUNDR (Sheet 9 of 9)

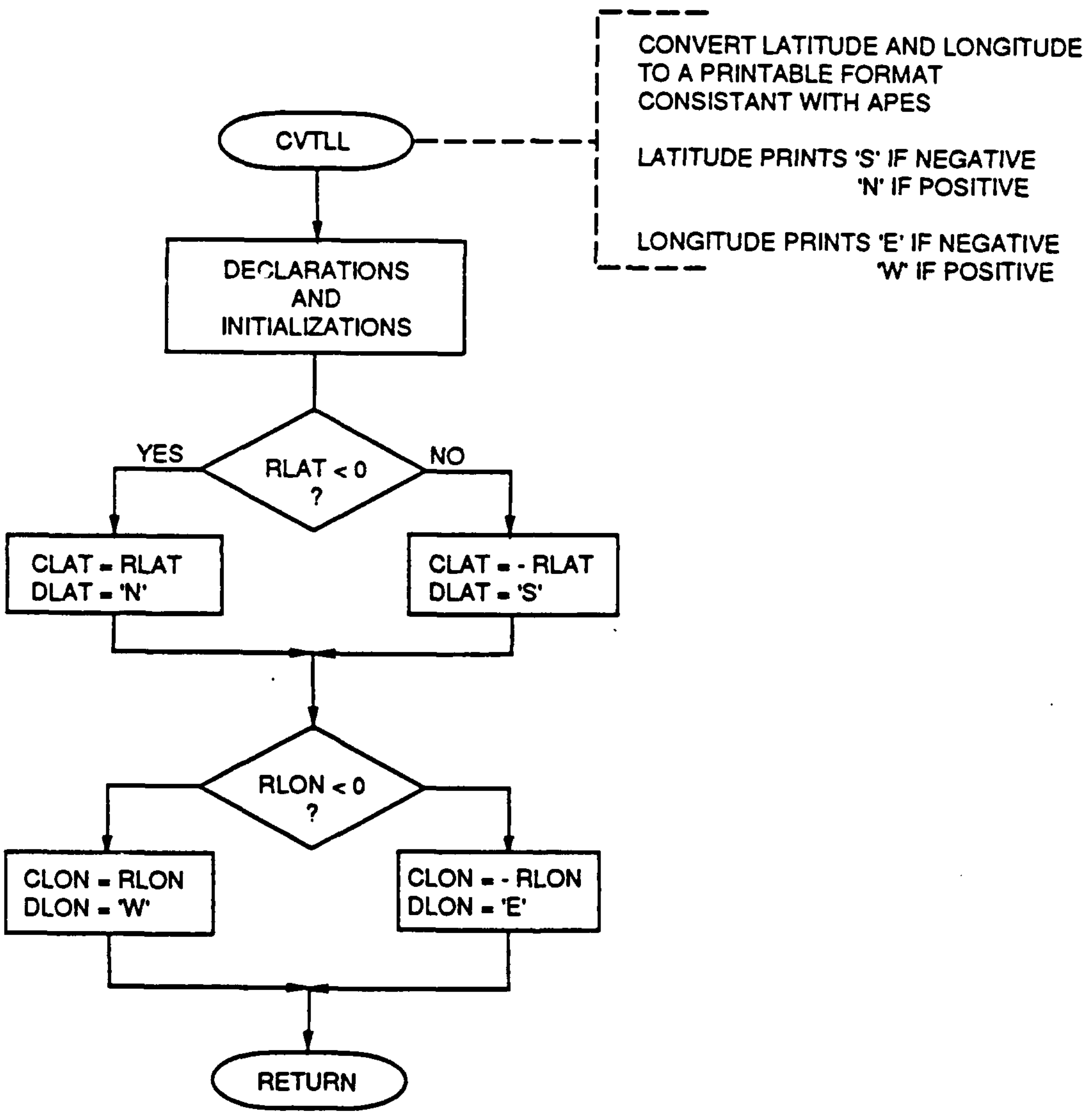


Figure 16. Subroutine CVTLL

The Sun Spot Number (SSN) and related 10.7 cm flux values are obtained by adjusting the computed MUF for the sounder path, by varying the SSN until it agrees with the supplied MOF, or until 50 iterations have been completed.

The SSN is then reset to zero and then continually increased by units of 10 until the resultant MUF value realized by the MUF85 model calculations exceed the supplied MOF value, or until the SSN exceeds 250.

The SSN is further adjusted, by performing a binary iteration on the resultant MUF value obtained from the MUF85 model, until the difference between this MUF value and the originally supplied MOF value is .0005, or until 50 iterations have occured. The 10.7 cm flux value is then computed, based on this new SSN.

The original and final SSN's and 10.7 cm flux values are printed out. The user is prompted as to whether or not the final values should be used to replace the orginal values in permanent TDA memory, to be used by this and all other TDA modules.

The user is then prompted to repeat these calculations using a different MOF at the same sites. If he responds with a 'y' then the entire process repeats; otherwise the sounder update module terminates, and control is returned to the calling process (either the REal-time module or the TDA main program)

2.3.3.3 Output

1. The updated SSN value (if the user responds 'y' to the update request)

2. The corresponding 10.7 cm flux value

2.3.4 References

1. NOSC TD 782, Tactical Decision Aids for HF Communication, by D.B. Dailors, 15 November 1984.

2. NOSC TD 1065, Operational User's Manual for Tactical Decision Aids for HF Communication, by D.B. Sailors, July 1987.

3. NOSC Contractor Report CR 292, Operational Users Manual for Army PROPHET Evaluation System (APES)/Theater Nuclear Forces (TNF) Frequency Managment System, prepared by J.R. Gnessin, Systems Exploration, Inc., July 1985.

4. NOSC Contractor Report (unpublished), Program Package Document for the Army PROPHET Evaluation System (APES)/Theater Nuclear Forces (TNF) Freqeuncy Management System, prepared by J.R. Gnessin, Systems Exploration, Inc., Oct 1985.

5. HP FORTRAN/77 Reference Manual, Hewlett-Packard 97081-90010, June 1985

6. HP-UX Reference, HP9000 Series 500 Computers, HP-UX Release 5.2, Hewlett-Packard 09000-90010, Edition 1, April 1987.

SECTION 3
TESTING

3.1 SU TEST

3.1.1 Purpose

The purpose of testing the SU module is to verify that the SU module, as translated from the APES Tektronix BASIC to TDA HP 9050 FORTRAN, operates in essentially the same manner in both systems. Because of differences in the method of MUF computations in the two systems, intermediate results cannot be effectively compared -- namely the pseudo sunspot numbers computed under the different methods. However, the purpose of the SU module is to shift the MUF curve so that the MUF equals (or approximately equals) the MOF at the measured time. Thus, the purpose of the test is to demonstrate that SU module performs this function in the HP 9050 TDA and differences in the pseudo sunspot numbers are considered irrelevant.

3.1.2 Procedure

Testing the SU module consisted of entering selected MOF's and verifying that the SU module operates as intended. The data was for a sounder path from Isabela, Puerto Rico to Norfolk, VA on 15 and 16 November, 1981. Data was obtained from the following report: NRL Memorandum Report 5284, H.F. Frequency Management by Frequency Sharing as Assisted by Models Updated in Real-Time, by D.R. Uffelman and L.O Harnish, SRI International, and J.M. Goodman, E.O. Hulburt Center for Space Research, Ionospheric Effects Branch, Space Science Division, March 21, 1984.

3.1.3 Results and Conclusions.

In general, when a MOF value was entered into the system via the SU module prompt, the SU module produced a pseudo sunspot number. Then, when the pseudo sunspot number was entered into the system to replace the previous sunspot number, the system computed a corresponding MUF which was equal or nearly equal to the original MOF.

The test demonstrated that the MOF's on the particular days and paths selected stressed the model to its upper limits. The model provides for sunspot numbers up to 250. In many cases, using measured MOF's for the selected path and times, the computed pseudo sunspot number exceeded the upper limit. For those MOF's which were in range (approximately 15 MHz or less during early day time hours) the model worked as intended. When the MOF was out of range, the model could not produced an equivalent MUF.

The bounding contraints of the SU model are included by design to avoid ambiguous results. The physical relationship of

MUF to sunspot number is that MUF increases with increasing sunspot number to a maximum value (saturation) and then begins to fall. Thus, the model cuts off further computations at the saturation level. The SU code was modified to test for MOF's above the maximum allowable value for the given path and time and provide a prompt to the user when the value was exceeded.

The model performed as intended for those MOF's which were in range. For comparison, selected MOF's were also entered on the Tektronix 4052 containing the APES model, and results were comparable (though not identical due to differences in versions of MUF 85 used in the models).

3.2 FS TEST

3.2.1 Purpose

The purpose of testing the FS module is to verify that the predicted field strength outputs of the upgraded model are more closely aligned with observed data than those of the previous version of the model. This would then demonstrate that the enhancements to the model actually improved the accuracy of the model. It is generally presumed that if the accuracy improved, the physical assumptions used in the enhanced model were correct. Conversely, if the accuracy of the predicted outputs were degraded, then the assumptions would have been incorrect. This also presumes that the observed data was correctly recorded.

The CCIR data base was used to provide the observed data which was then used for comparison with predicted outputs obtained from the model.

3.2.2 Procedure

Figure 17 illustrates an overview of the sequence of testing activities for the FS module with approximate times required to accomplish each major task. Testing activities are described below:

a. The FS module was first developed and tested on the VAX. Modifications were incorporated as described earlier in this report. The upgraded model was then run on the VAX and data outputs were evaluated for general credibility. This was accomplished by manually comparing the predicted FS data results for long paths with selected data available from the previous version of the FS model. For short path lengths, no similar data comparison was possible as this was outside the region of operability of the previous model. However, various manual methods were used to determine general credibilitiy, such as reviewing published reports and performing manual calculations to determine conformance with theory and selected empirical data.

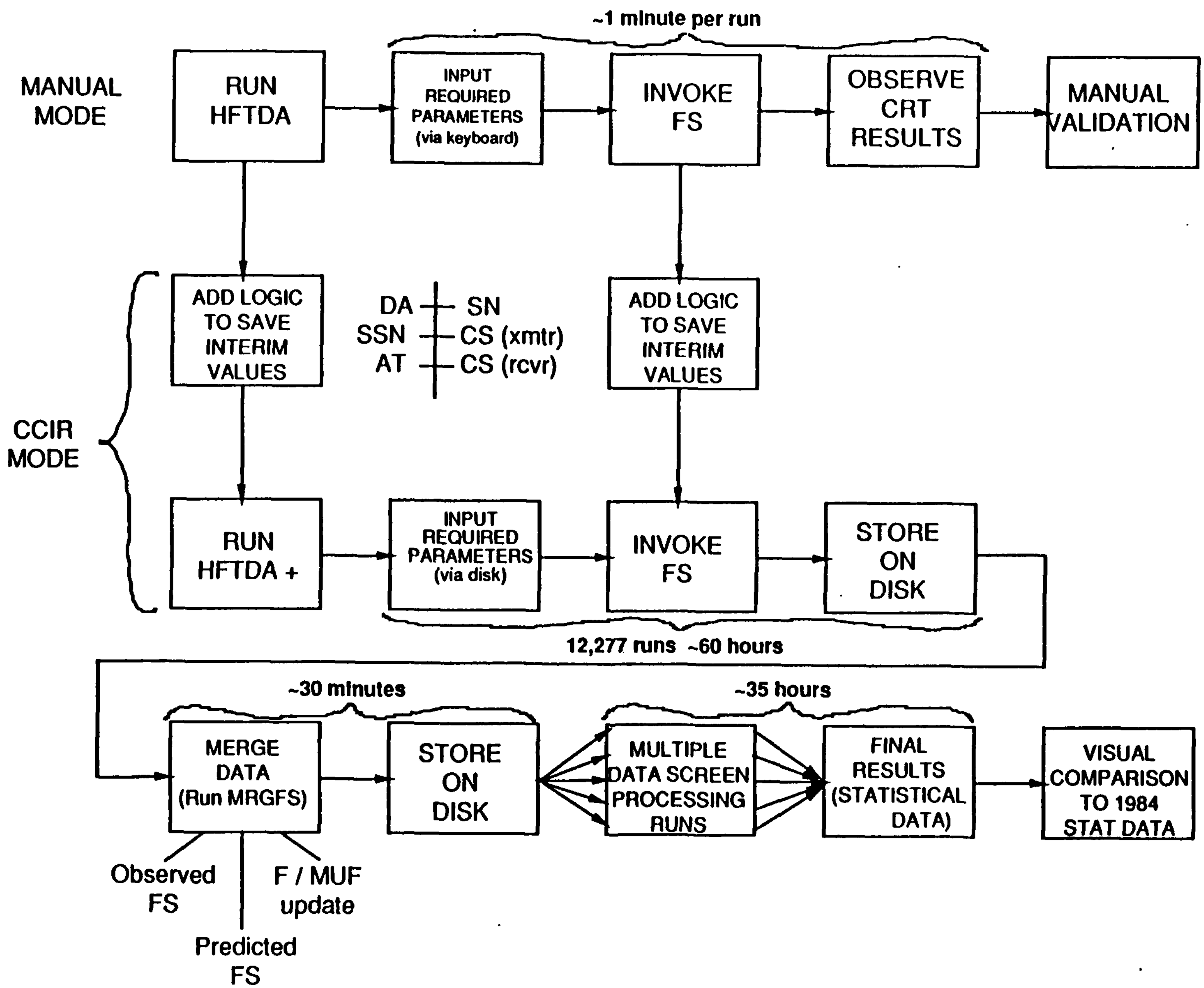


Figure 17. Sequence of Activities to test Field Strength Module

b. The FS module was then integrated into the HP 9050 version of TDA and run in a standard operator-interactive mode. Visual observations of the outputs on the CRT were compared with results of similar runs made on the VAX to determine that the model performed satisfactorily as intended. Note that this test did not validate the accuracy of results as compared with real world data; only that the HP 9050 version was functionally identical to the VAX developmental model. This test was necessary to determine that the translation from VAX to 9050 was correct. It also tests the operational version of the model characterized by two dimensional tabular/graphic outputs of field strength computed as functions of time and frequency.

c. The FS module was then modified to provide outputs suitable for comparison with the CCIR data base. This modification was also necessary to adapt the model to accept a series of inputs stored in a command file which would be used to drive the model into producing the desired set of outputs for comparison.

Table 1 illustrates one page of this command file. The left column is the actual command file except for bracketed explanations included here for clarification. The right column illustrates the system prompts corresponding to the commands. The command file and the statistical computation files were previously established by NOSC personnel for the purpose of comparing previous versions of FS module and other related modules.

The most significant modification to the test version of the FS module was to change the output for one dimensional data: field strength versus time with frequency fixed to correspond to one of the frequencies associated with the measured CCIR data. Table 2 illustrates a sample of this output. Bracketed column heads were added to the table for clarification. The Predicted FS versus UT (universal time) data shown in Table 2 generally corresponds to a single row of the conventional FS module output. Conventional output is a two dimensional table (FS as a function frequency and time). A difference is that the frequency on the modified FS module output table is repesented as a real decimal to tenths of a MHz, whereas choices on the conventional frequency-indexed output are limited to even integer values (actually rounded internally) between 2 and 30 MHz. It is noted here that the CCIR data is actually constrained further in that it is not avialable for all possible times but only a subset.

d. The modified FS module was then run using the command file. The command file automatically provides the set of inputs corresponding to the CCIR database observation parameters and generate the set of data outputs to be used for comparison with the CCIR observed data. This run takes approximately 60 hours to complete and was performed either in a background/batch mode or run on weekends to avoid disrupting ongoing operations at the NOSC HP 9050 computer center.

Table 1. Sample Page of FS Command File and Corresponding System Prompts

COMMANDS/RESPONSES	SYSTEM PROMPTS (Abbreviated)
2 [2=ALPHANUMERIC CRT]	PLEASE SELECT [TERMINAL] TYPE NUMBER
n	WOULD YOU LIKE AN INTRODUCTION (Y/N)
cs [change station]	:>
hono [station name, transmitter = Honolulu]	CS>
49.40 [latitude]	CS>
-6.19 [longitude]	CS>
0 [antenna number]	CS>
1000 [power]	CS>
[blue force]	CS>
0 [speed]	CS>
cs [change station]	
sdiego [station name, receiver = San Diego]	
51.07	
-7.16	
0	
1000	
0	
da [date analyzed]	:>
8 [month]	da>
15 [day]	da>
84 [year]	da>
fr [operating frequency]	:>
6.1 [minimum]	fr>
[maximum]	fr>
ssn [sun spot number]	:>
25.	ss>
fs [field strength]	:>
s [signal strength table]	
[display next 12 hours of data]	
e [end]	
da	
9	
15	
84	
fr	
6.1	

Table 2. Data File tstnew Sample

XMTR: LAT: 49.4 LON: -6.2 SSN: 25. 8/1984
RCVR: LAT: 51.1 LON: -7.2

[Universal Time]	[Local Mean Time]	[Predicted FS]	[Frequency]	[LUF]	[MUF]	[Operational MUF]
0	.44440	-1.00000	6.10000	2.00000	3.82359	8.27617
1	1.44440	-3.00000	6.10000	2.00000	3.54893	7.73089
2	2.44440	-10.00000	6.10000	2.00000	2.91485	6.39008
3	3.44440	-6.00000	6.10000	2.00000	3.21894	7.10139
4	4.44440	1.00000	6.10000	2.00000	4.29077	9.52552
5	5.44440	19.00000	6.10000	2.00000	4.94040	10.85344
6	6.44440	25.00000	6.10000	2.00000	5.37735	11.68901
7	7.44440	27.00000	6.10000	2.00897	5.68215	12.22018
8	8.44440	27.00000	6.10000	2.29286	5.89435	12.54024
9	9.44440	27.00000	6.10000	2.49826	6.03582	12.86912
10	10.44440	30.00000	6.10000	2.63299	6.11955	13.07596
11	11.44440	30.00000	6.10000	2.70455	6.15365	13.17727
12	12.44440	30.00000	6.10000	2.71260	6.14320	13.18331
13	13.44440	27.00000	6.10000	2.65728	6.09132	13.01563
14	14.44440	27.00000	6.10000	2.53916	5.99958	12.76410
15	15.44440	27.00000	6.10000	2.35160	5.86812	12.43015
16	16.44440	27.00000	6.10000	2.08837	5.69551	12.01183
17	17.44440	26.00000	6.10000	2.00000	5.47800	11.57844
18	18.44440	24.00000	6.10000	2.00000	5.20800	11.03184
19	19.44440	19.00000	6.10000	2.00000	4.87000	10.33840
20	20.44440	5.00000	6.10000	2.00000	4.42816	9.42092
21	21.44440	1.00000	6.10000	2.00000	4.23241	9.04360
22	22.44440	-1.00000	6.10000	2.00000	3.82012	8.19799
23	23.44440	.00000	6.10000	2.00000	3.86374	8.32732

XMTR: LAT: 49.4 LON: -6.2 SSN: 15. 9/1984
RCVR: LAT: 51.1 LON: -7.2

0	.44440	-7.00000	6.10000	2.00000	3.12210	7.27761
1	1.44440	-9.00000	6.10000	2.00000	3.00113	6.89848
2	2.44440	-10.00000	6.10000	2.00000	2.86469	6.49210
3	3.44440	-14.00000	6.10000	2.00000	2.53986	5.67374
4	4.44440	-3.00000	6.10000	2.00000	3.62395	7.97812
5	5.44440	14.00000	6.10000	2.00000	4.70086	10.37070
6	6.44440	24.00000	6.10000	2.00000	5.19650	11.48817
7	7.44440	26.00000	6.10000	2.00000	5.50159	12.18809
8	8.44440	27.00000	6.10000	2.17407	5.69744	12.64832
9	9.44440	27.00000	6.10000	2.41428	5.81504	12.85561
10	10.44440	27.00000	6.10000	2.56677	5.86952	12.92175
11	11.44440	26.00000	6.10000	2.64034	5.86908	12.86649
12	12.44440	26.00000	6.10000	2.63825	5.81817	12.70108

Table 3. Data File fsdb.hfbc Sample

[Data base code] [101=HFBC84 (used for LTLFLD model)]
[Number of data base fields]
[Total data base records]
[Data base title]

101 10 12277 HFBC84 Field Strength model

[Path ID]
[Circuit Length]
[Season: 1=Winter, 2=Spring, 3=Summer, 4=Fall]
[Orientation: 0=other, 1=North/South, 2=East/West]
[Smoothed SSN]
[Mid path latitude]
[Mid path local time]
[Freq/MUF ratio]
[Observed Field Strength]
[Predicted Field Strength]

1	175	3	0	42	50.2	6.4	1.2	23.0	32.0
1	175	3	0	42	50.2	7.4	1.0	22.0	33.0
1	175	3	0	42	50.2	8.4	1.0	22.0	31.0
1	175	3	0	42	50.2	9.4	.9	30.0	30.0
1	175	3	0	42	50.2	10.4	.9	32.0	30.0
1	175	3	0	42	50.2	11.4	.9	29.0	29.0
1	175	3	0	42	50.2	12.4	.9	24.0	29.0
1	175	3	0	42	50.2	13.4	1.0	23.0	29.0
1	175	3	0	42	50.2	14.4	1.0	26.0	30.0
1	175	3	0	42	50.2	15.4	1.0	25.0	31.0
1	175	3	0	42	50.2	16.4	1.0	27.0	31.0
1	175	3	0	42	50.2	17.4	1.0	36.0	33.0
1	175	3	0	42	50.2	18.4	.9	43.0	35.0
1	175	3	0	42	50.2	19.4	.9	44.0	37.0
1	175	4	0	40	50.2	7.4	1.1	17.0	32.0
1	175	4	0	40	50.2	8.4	1.0	16.0	31.0
1	175	4	0	40	50.2	9.4	.9	20.0	30.0
1	175	4	0	40	50.2	10.4	.9	24.0	31.0
1	175	4	0	40	50.2	11.4	.9	23.0	30.0
1	175	4	0	40	50.2	12.4	.9	23.0	30.0
1	175	4	0	40	50.2	13.4	.9	24.0	31.0
1	175	4	0	40	50.2	14.4	.9	24.0	32.0
1	175	4	0	40	50.2	15.4	.9	25.0	33.0
1	175	4	0	40	50.2	16.4	.9	30.0	34.0
1	175	4	0	40	50.2	17.4	.9	34.0	36.0
1	175	4	0	40	50.2	18.4	.9	37.0	37.0
1	175	4	0	40	50.2	19.4	1.0	35.0	38.0
1	175	4	0	38	50.2	6.4	1.3	27.0	28.0
1	175	4	0	38	50.2	7.4	1.0	23.0	36.0
1	175	4	0	38	50.2	8.4	.9	26.0	35.0
1	175	4	0	38	50.2	9.4	.8	33.0	33.0
1	175	4	0	38	50.2	10.4	.8	38.0	34.0

e. Output data were then reformatted and moved into correctly named files and directories to be CCIR compatible. This was accomplished as follows:

1. The format of the CCIR compatible field strength data base file for use in the statistical filter program is shown in Table 3. For presentation purposes here, the format in the table has been modified to include column descriptions in brackets. Table 3 is a condensed form of the complete CCIR data base. A sample of the complete CCIR database is shown in Table 4 (format modified with bracketed descriptors for clarity). Path information for the CCIR database is given in Appendix B.

Table 3 also includes, in the last column, the predicted value of field strength from a previous version of the FS module. That data was ignored and overwritten with the new predicted values, as described below.

2. A problem with the format of Table 3 is that is it does not list a unique identifier, such as universal time (UT). A program was written (Appendix C) to merge the UT and other selected parameters with the data in Table 3 and also add the predicted FS values from the new model run. A sample of the end result is shown in Table 5. (Bracketed descriptors are included for clarity.)

f. Before running the statistical data filter (TURBO program) which generally takes 40 to 50 hours to run, various manual checks were performed to reasonably assure that the run would provide useful results. These checks consisted of spot comparisons of field strength outputs from the modified FS module with comparable field strength data in the CCIR data base. If these checks showed reasonable comparisons -- most within about 10 to 20% or less -- the statistical run was performed. Otherwise, the module was reviewed to determine the problem. The problems fell into various categories, including logical errors, incorrect formats, and roundoff errors. Once these errors were isolated and corrected, the statistical run was performed.

g. The statistical run consisted of running the statistical data filter program using the formatted data as described above. This run took approximately 40 to 50 hours and produced line printer listing which could then be compared visually. To aid in data analysis, a program was written (mtable, included in Appendix D). This program reformatted the outputs from both the original hfbc84 runs and the new LTLFLD outputs into summary table formats. An analysis of the these tables is included in 3.2.3.

Table 4. Data File fsccir4 Sample

```
[Universal Time]
 [Month]
  [Year]
   [Monthly Median SSN]
    [Path Length]
     [Receiver Latitude]
         [Receiver Longitude]

    6.        8.     1984.      25.     175.     51.07     -7.16

[Latitude, Path Midpoint]
 [Transmitter Latitude]
  [Transmitter Longitude]
   [Unused]
    [Operating Frequency]
     [Operating Freqeuncy/LUF]
      [LUF/MUF]

  6.4      49.40    -6.19       .0      6.1       3.0       .4

[Observed Field Strength]
 [Operating Frequency/Operational MUF]
  [12 Month Running Mean SSN]
   [LUF]
    [Operating Frequency/MUF (MUF from MUF85)]
     [Operational MUF]
      [unused]
       [Data ID (0 OBS, TDA FLD STR)]
        [Path ID]

   23.0        .5     42.0      2.0      1.1      11.7 0    0    1

    7.         8.    1984.      25.     175.     51.07     -7.16
    7.4     49.40    -6.19       .0      6.1       3.0       .4
   22.0        .5     42.0      2.0      1.1      12.2 0    0    1

    8.         8.    1984.      25.     175.     51.07     -7.16
    8.4     49.40    -6.19       .0      6.1       2.7       .4
   22.0        .5     42.0      2.3      1.0      12.5 0    0    1

    9.         8.    1984.      25.     175.     51.07     -7.16
    9.4     49.40    -6.19       .0      6.1       2.4       .4
   30.0        .5     42.0      2.5      1.0      12.9 0    0    1
```

Table 5. Data File merg.hfbc Sample

```
Feb 07 21:28 1988  merg.hfbc

[Data base code] [101=HFBC84 (used for LTLFLD model)]
[Number of data base fields]
[Total data base records]
[Data base title]

0   10   12277  HFBC84 Field Strength model

[Path ID]
[Circuit Length]
[Season: 1=Winter, 2=Spring, 3=Summer, 4=Fall]
[Orientation:  0=other, 1=North/South, 2=East/West]
[Smoothed SSN]
[Mid path latitude]
[Mid path local time]
[Operational Freq/MUF ratio]
[Observed Field Strength]
[Predicted Field Strength]
[Universal time]
[Month]
[Year]
[Operational Freq/Operational MUF]
[Monthly Mean SSN]
                                                       [Freq]
1   175 3 0  42   50.2  6.4 1.2  23.0  25.0  6  6.1  8 1984  1.1  25.0
1   175 3 0  42   50.2  7.4 1.0  22.0  27.0  7  6.1  8 1984  1.1  25.0
1   175 3 0  42   50.2  8.4 1.0  22.0  27.0  8  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2  9.4  .9  30.0  27.0  9  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 10.4  .9  32.0  30.0 10  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 11.4  .9  29.0  30.0 11  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 12.4  .9  24.0  30.0 12  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 13.4 1.0  23.0  27.0 13  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 14.4 1.0  26.0  27.0 14  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 15.4 1.0  25.0  27.0 15  6.1  8 1984  1.0  25.0
1   175 3 0  42   50.2 16.4 1.0  27.0  27.0 16  6.1  8 1984  1.1  25.0
1   175 3 0  42   50.2 17.4 1.0  36.0  26.0 17  6.1  8 1984  1.1  25.0
1   175 3 0  42   50.2 18.4  .9  43.0  24.0 18  6.1  8 1984  1.2  25.0
1   175 3 0  42   50.2 19.4  .9  44.0  19.0 19  6.1  8 1984  1.3  25.0
1   175 4 0  40   50.2  7.4 1.1  17.0  26.0  7  6.1  9 1984  1.1  15.0
1   175 4 0  40   50.2  8.4 1.0  16.0  27.0  8  6.1  9 1984  1.1  15.0
1   175 4 0  40   50.2  9.4  .9  20.0  27.0  9  6.1  9 1984  1.0  15.0
1   175 4 0  40   50.2 10.4  .9  24.0  27.0 10  6.1  9 1984  1.0  15.0
1   175 4 0  40   50.2 11.4  .9  23.0  26.0 11  6.1  9 1984  1.0  15.0
1   175 4 0  40   50.2 12.4  .9  23.0  26.0 12  6.1  9 1984  1.0  15.0
1   175 4 0  40   50.2 13.4  .9  24.0  25.0 13  6.1  9 1984  1.1  15.0
1   175 4 0  40   50.2 14.4  .9  24.0  25.0 14  6.1  9 1984  1.1  15.0
```

3.2.3 Results and Conclusions

The results of the FS module tests are shown in Appendix E, tables E-1 through E-25. Table E-1 shows the overall results for all 81 paths at all frequencies recorded in the database. The results are satisfying and show the new field strength method (LTFLD) to have much lower average residuals than the old method (DMBLT). The RMS residual is also better by at least a factor of two to one. The correlation coefficient is better but the improvement is not as pronounced. This could be caused by a time lag in the prediction relative to the observed data; however this has not been verified. The most pronounced improvement seems to be in the over-the-MUF calculations which show a much lower average residual of approximately one-fifth and an RMS residual of less than one-half.

These results look encouraging; however, when one inspects Table E-2 it can be seen that the shape of the distribution of losses above the MUF is not that of a normal curve, but possibly an exponential curve as suggested by Damboldt and Sussman. The scatter fields (well above 1.4 times the MUF) are stronger than predicted. A revised method for over-the-MUF computations has been postulated but time and resources did not allow checks with the data base.

Inspection of Tables E-11 through E-13, which are a function of path length, shows that an improvement has been made for the very short paths (less than 1000 km) with an average residual of about one-fifth the older value. This was a major concern of the project. The RMS residuals show good improvement; however,the correlation coefficient, while showing good improvement in general, looks very bad for paths between 2000 and 3000 km. It is suspected that paths of this length should be easily predictable. Further inspection shows that only 1.2% of the data base was used to determine these values of comparison. Also, this distance is the "crossover" region for the one-hop E-layer mode and the one-hop F2-layer or 2-hop E-layer mode. These modes change from day-to-day due to changing ionospheric heights and critical frequencies. This may help to explain the low correlation coefficient, but this has not been analyzed further.

A very similar trend is shown between 4000-5000 km ranges, which is the "crossover" point for one-hop and two-hop f2-layer propagation. The antenna patterns are sensitive to these changing modes due to vertical takeoff angle associated with the modes available day-to-day.

Only 0.9% of the data was used in the analyses for the above range of 4000-5000 km suggesting that more data would be useful to make a detailed analysis of the trend.

The over-the-MUF calculation shown in Table E-12 as a function of path length shows large average residuals for the same distances. This suggests the same conclusion as above because an error in calculating the MUF for the path as a one or two hop will cause a more than usual error at these distances. The data tends to suggest the MUF was consistently lower than that of the observed data. In other words, over-the-MUF losses were calculated when in fact the path observed was operating below-the-MUF. This has not been verified and it is doubtful that data is available to verify the assumption.

Another possibility is the data recorded may be only on those days that the signal was readable above the noise; hence below the MUF for the path. If all 30 days at a given hour are not present in the day it is difficult to tell what part of the distribution it represents. There is no intent to blame the data for bad predictions, but rather to cite things that can be looked at to improve the overall predicition process.

The large errors occurring when very few hours were recorded may be due to an insufficiently large sample size to produce meanifull statistics. Although included here for completeness, they are bothersome. It is suggested that these data be eliminated for analysis purposes that do not a least come close to the hourly median of the monthly median values, even though this violates the desire for a large data base. The smaller data base may be of more value in updating the prediction methods.

The model for field strength predicitions within HFTDA is highly modular and should allow easily checking different algorithms for all the losses associated with the system loss and field strength calculations.

3.3 Recommendations

The availability of a highly modular field strength model should facilitate checking many options, specific models for given parameters, and results of these calculations. We suggest checking any changes with limited circuits from the CCIR database. It would be preferrable to use those circuits with many hours of data even if some path lengths are avoided in the initial checks of any parameter.

Worthwhile items to be revised and checked with observations are:

1.) Shultz-Gallet absorption equation
2.) Dambolt over-the-MUF exponential distribution
3.) Revised JTAC model for scatter fields above about 1.4*MUF
4.) Daytime low-frequency specular reflection algorithhm
5.) F2-layer height calculation
6.) High-latitude description of losses
7.) Rise-time of the MUF of MUF-85 near mid-day
8.) E-layer algorithm for MUF

These are not necessarily in the order of priority. They represent potential areas of model enhancement which could lead to expected improvements in the predictions.

These changes should be made to see which algorithm shows the best fit with the overall data, to make HFTDA a true predictor of field-strengths. Care should always be taken to avoid using a limited amount of data taken in a specific location to draw conclusions aside from the physics of the matter. A curve fitting process which is not founded on long-term emperical data and physics could be non-productive while showing very good statistical data of which many transmitting and receiving variables are not known; especially as a function of time.

Since the MUF and vertical arrival angle were not recorded at the receiver in the CCIR database, the power and elevation angle gain at the transmitting antenna are of questionable validity over a period of time. It is recommended that the above remarks be kept in mind when deducing the validity of any checks against data to determine the accuracy of HF predictions for their varied purposes.

APPENDIX A. FLOWCHART SYMBOLOGY AND CONVENTIONS

Figure A-1 shows the flowchart symbology. In general, flowcharts use FORTRAN conventions to represent discrete programming steps. Assignments are indicated with an "=" sign, and mean the right value is assigned to the left value. The right value is unchaged. Thus,

A = B

means

B -> A

FORTRAN arithmetic symbols are used. Thus,

* - multiplication

+ - addition

- - subtraction

** - exponentiation

/ - division

In addition, the following functions or their equivalents are assumed to be available or easily programmed, and so are not separately charted.

LOG10	arithmetic LOG function, base 10
INT	floating point to integer type conversion function
MAX,MIN	return maximum or minimum value from a list
COS, SIN, TAN, SEC	the trigonometric functions
ATAN	the inverse tangent trigonometric functions
SQRT	the square root function
ABS	the absolute value function

THE FOLLOWING SYMBOLS HAVE BEEN USED IN THESE FLOWCHARTS.

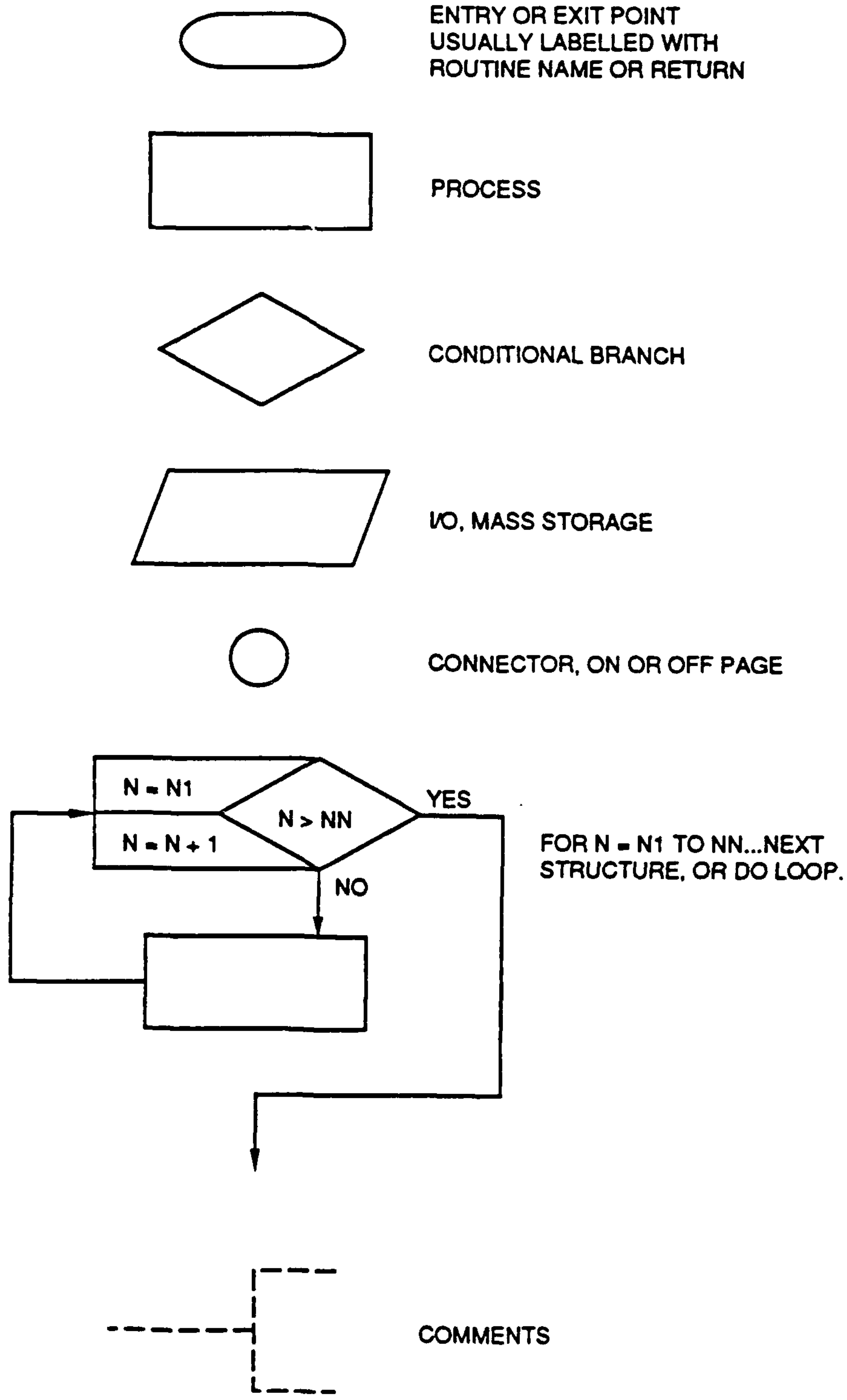


Figure A-1 Flowchart Symbology

APPENDIX B
PATH INFORMATION FOR THE CCIR DATABASE

Path Information for the HFBC84 Field Strength Database

ID	TRANSMTR LATTITUDE	TRANSMTR LONGITUD	MID PATH LATTITUDE	MID PATH LONGITUD	RECEIVER LATTITUDE	RECEIVER LONGITUD	AZIMUTH	CKT LENGTH	HOURS TOTAL	HOURS BELOW	HOURS ABOVE	MIN VALUE	MAX VALUE
1	49.40	-6.19	50.24	-6.67	51.07	-7.16	20.32	175	54	46	8	2.0	44.0
2	36.11	-139.51	37.78	-139.79	39.44	-140.08	7.75	396	380	344	36	-8.0	39.0
3	35.41	-139.31	37.43	-139.68	39.44	-140.08	8.62	454	960	829	131	1.0	50.0
4	26.55	-88.19	24.41	-88.18	22.27	-88.18	179.75	497	4	4	0	27.0	33.0
5	52.03	1.13	52.76	-2.91	53.34	-7.07	75.20	585	1169	352	817	-48.0	54.0
6	52.03	1.13	51.62	-3.06	51.07	-7.16	100.58	595	50	24	26	-48.0	36.0
7	47.00	-2.00	49.06	-4.47	51.07	-7.16	39.65	597	58	51	7	-13.0	50.0
8	59.26	-10.36	56.31	-8.59	53.34	-7.07	197.02	686	415	90	325	-48.0	41.0
9	59.26	-10.36	55.93	-10.78	52.59	-11.13	176.33	718	89	26	63	-50.0	33.0
10	52.03	1.13	52.47	-4.96	52.59	-11.13	85.70	847	967	343	624	-50.0	50.0
11	34.12	-108.54	36.91	-112.27	39.57	-116.27	48.52	925	12	11	1	-11.0	44.0
12	17.20	-78.33	12.75	-77.44	8.29	-76.59	190.76	999	12	12	0	16.0	32.0
13	36.11	-139.51	40.67	-140.40	45.23	-141.41	8.92	1035	170	143	27	-44.0	41.0
14	39.57	-116.27	35.39	-118.91	31.15	-121.29	154.19	1069	145	140	5	-24.0	40.0
15	50.25	4.49	51.68	-3.12	52.59	-11.13	76.37	1139	246	45	201	-50.0	39.0
16	34.12	-108.54	32.80	-115.02	31.15	-121.29	105.53	1221	108	108	0	-12.0	41.0
17	-17.19	-123.39	-20.33	-128.30	-23.32	-133.41	123.19	1253	154	146	8	-27.0	47.0
18	19.11	-72.49	13.71	-74.59	8.29	-76.59	159.86	1272	2	2	0	25.0	34.0
19	52.42	8.54	52.91	-1.28	52.59	-11.13	89.17	1347	312	271	41	-16.0	43.0
20	61.28	-21.52	56.38	-13.38	51.07	-7.16	217.26	1455	39	39	0	-1.0	40.0
21	36.42	-3.11	43.76	-4.89	51.07	-7.16	11.06	1635	4	4	0	28.0	58.0
22	7.06	-79.54	14.70	-83.71	22.27	-88.18	28.59	1930	6	6	0	.1	30.0
23	20.36	-58.53	24.68	-67.53	28.43	-77.12	64.31	2056	35	35	0	13.0	34.0
24	39.54	-30.42	43.62	-19.18	46.46	-6.57	292.07	2057	6	6	0	23.0	44.0
25	40.58	-24.21	46.61	-13.04	51.31	.57	302.76	2255	2	2	0	22.0	37.0
26	20.36	-58.53	14.50	-67.81	8.29	-76.59	124.85	2365	8	8	0	22.0	28.0
27	39.54	-30.42	45.72	-18.28	50.33	-3.56	300.45	2389	8	8	0	21.0	43.0
28	7.06	-79.54	17.75	-78.40	28.43	-77.12	353.94	2420	3	3	0	8.0	21.0
29	16.37	-120.17	27.98	-118.43	39.57	-116.27	351.77	2621	11	11	0	-5.0	39.0
30	15.21	-120.37	27.40	-118.55	39.57	-116.27	351.73	2765	53	53	0	-1.0	31.0
31	-4.36	-55.28	2.00	-65.89	8.29	-76.59	59.04	2795	12	12	0	8.0	26.0
32	1.25	-103.44	11.86	-96.11	22.27	-88.18	325.03	2873	5	5	0	25.0	30.0
33	1.25	-103.44	4.90	-90.09	8.29	-76.59	284.89	3064	14	14	0	22.0	28.0
34	32.04	-34.47	43.00	-19.68	51.31	.57	308.31	3611	10	10	0	18.0	44.0
35	35.41	-51.27	45.75	-34.25	52.59	-11.13	302.84	3665	89	83	6	-33.0	46.0
36	35.41	-51.27	45.38	-32.21	51.07	-7.16	297.97	3886	106	106	0	-21.0	38.0
37	35.41	-51.27	46.50	-32.76	53.34	-7.07	302.02	3945	488	412	76	-67.0	41.0
38	1.25	-103.44	15.22	-91.14	28.43	-77.12	317.86	4139	23	23	0	12.0	33.0
39	1.25	-103.44	20.53	-109.02	39.57	-116.27	16.49	4474	65	65	0	-2.0	31.0
40	45.53	64.19	53.37	34.45	52.00	.08	79.83	4582	1	1	0	1.0	15.0

Path Information for the HFBC84 Field Strength Database (cont)

ID	TRANSMTR LATITUDE	TRANSMTR LONGITUD	MID PATH LATITUDE	MID PATH LONGITUD	RECEIVER LATITUDE	RECEIVER LONGITUD	AZIMUTH	CKT LENGTH	HOURS TOTAL	HOURS BELOW	HOURS ABOVE	MIN VALUE	MAX VALUE
41	29.16	-47.53	42.74	-27.71	51.31	.57	303.99	4700	1	1	0	13.0	34.0
42	-7.54	14.23	-17.91	-5.58	-26.06	-27.55	115.72	4902	24	24	0	12.0	43.0
43	45.53	64.19	54.08	30.75	51.07	-7.16	81.92	5095	16	14	2	-6.0	33.0
44	45.53	64.19	51.78	29.15	46.46	-6.57	88.70	5277	3	3	0	13.0	39.0
45	41.42	70.00	54.14	36.63	53.34	-7.07	73.78	5632	756	623	133	-69.0	38.0
46	45.53	64.19	61.39	29.22	60.34	-25.00	68.00	5671	4	3	1	-20.0	14.0
47	22.00	159.48	32.74	-172.75	36.22	-140.38	286.57	5906	710	698	12	-14.0	28.0
48	41.42	70.00	54.58	34.57	52.59	-11.13	75.24	5910	166	142	24	-68.0	22.0
49	-12.25	-130.37	13.76	-124.16	39.57	-116.27	346.40	6004	1	1	0	10.0	13.0
50	35.35	77.22	50.51	45.01	52.00	.08	69.25	6150	1	0	1	-5.0	13.0
51	35.35	77.22	50.45	42.75	50.33	-3.56	71.99	6468	3	2	1	-2.0	25.0
52	-1.21	-36.54	26.21	-26.98	52.59	-11.13	339.94	6497	435	392	43	-35.0	42.0
53	36.48	76.30	53.46	40.17	52.59	-11.13	70.51	6690	655	527	128	-70.0	32.0
54	52.15	1.08	47.23	-46.25	28.43	-77.12	117.10	6756	7	7	0	8.0	19.0
55	34.43	-33.19	4.19	-30.25	-26.06	-27.55	184.80	6787	8	8	0	3.0	50.0
56	35.35	77.22	49.25	39.65	46.46	-6.57	77.30	6825	2	0	2	9.0	25.0
57	17.06	61.48	39.03	35.20	51.07	-7.16	53.62	7082	23	23	0	4.0	30.0
58	-24.54	-113.43	2.05	-95.59	28.43	-77.12	328.00	7126	18	18	0	1.0	32.0
59	-24.54	-113.43	7.52	-114.73	39.57	-116.27	2.23	7217	14	14	0	9.0	27.0
60	35.35	77.22	59.29	42.99	60.34	-25.00	58.21	7238	2	0	2	-11.0	.1
61	48.05	-10.41	57.74	-68.72	39.57	-116.27	99.97	7807	14	10	4	-57.0	25.0
62	-7.54	14.23	27.62	1.40	60.34	-25.00	21.30	8355	3	2	1	-9.0	32.0
63	-36.20	-145.25	-16.71	-106.95	8.29	-76.59	307.49	8689	13	13	0	.0	16.0
64	-26.35	-28.08	12.56	-19.48	51.07	-7.16	347.91	8879	14	14	0	-15.0	21.0
65	-36.20	-145.25	1.74	-131.10	39.57	-116.27	342.19	8985	8	8	0	.0	34.0
66	35.46	-139.37	66.38	-92.43	53.34	-7.07	294.97	9083	945	607	338	-87.0	20.0
67	40.42	105.02	55.62	-195.10	36.22	-140.38	265.58	9144	307	261	46	-44.0	15.0
68	52.15	1.08	13.43	-15.99	-26.06	-27.55	164.09	9159	3	3	0	-9.0	37.0
69	-26.35	-28.08	13.19	-16.66	52.00	.08	344.34	9163	1	1	0	-13.0	12.0
70	-20.19	-57.31	17.46	-39.44	52.59	-11.13	334.25	9287	717	636	81	-101.0	34.0
71	54.44	2.54	14.65	-15.80	-26.06	-27.55	164.22	9459	4	4	0	-19.0	19.0
72	-.14	78.20	31.32	48.14	50.33	-3.56	47.94	9483	4	1	3	-15.0	27.0
73	-.14	78.20	32.37	47.40	51.07	-7.16	47.94	9721	15	10	5	-20.0	39.0
74	35.45	119.17	58.75	-181.56	39.57	-116.27	274.49	9849	17	16	1	-28.0	18.0
75	-36.20	-145.25	-4.68	-109.52	28.43	-77.12	318.63	10151	15	15	0	-25.0	16.0
76	-.14	78.20	40.64	49.69	60.34	-25.00	39.73	10754	2	0	2	-22.0	26.0
77	39.00	76.48	67.66	-208.74	36.22	-140.38	266.14	10798	48	26	22	-41.0	-9.0
78	-12.25	-130.37	34.07	-100.95	60.34	-25.00	323.66	12059	6	6	0	-20.0	29.0
79	-24.54	-113.43	23.42	-85.25	60.34	-25.00	328.45	12332	6	6	0	-27.0	9.0
80	-35.18	-149.12	21.74	-101.11	52.59	-11.13	320.53	16206	822	614	208	-62.0	22.0
81	-35.18	-149.12	24.12	-102.46	53.34	-7.07	321.79	16448	169	137	32	-33.0	15.0

Path Information for the PROPHET Field Strength Database

ID	TRANSMTR LATITUDE	TRANSMTR LONGITUD	MID PATH LATITUDE	MID PATH LONGITUD	RECEIVER LATITUDE	RECEIVER LONGITUD	AZIMUTH	CKT LENGTH	HOURS TOTAL	HOURS BELOW	HOURS ABOVE	MIN VALUE	MAX VALUE
1	49.40	-6.19	50.24	-6.67	51.07	-7.16	20.32	175	54	27	27	-4.0	44.0
2	36.11	-139.51	37.78	-139.79	39.44	-140.08	7.75	396	380	332	48	-8.0	44.0
3	35.41	-139.31	37.43	-139.68	39.44	-140.08	8.62	454	960	815	145	1.0	50.0
4	26.55	-88.19	24.41	-88.18	22.27	-88.18	179.75	497	4	4	0	27.0	33.0
5	52.03	1.13	52.76	-2.91	53.34	-7.07	75.20	585	1169	301	868	-99.0	54.0
6	52.03	1.13	51.62	-3.06	51.07	-7.16	100.58	595	50	3	47	-31.0	36.0
7	47.00	-2.00	49.06	-4.47	51.07	-7.16	39.65	597	58	46	12	5.0	50.0
8	59.26	-10.36	56.31	-8.59	53.34	-7.07	197.02	686	415	88	327	-99.0	41.0
9	59.26	-10.36	55.93	-10.78	52.59	-11.13	176.33	718	89	26	63	-99.0	38.0
10	52.03	1.13	52.47	-4.96	52.59	-11.13	85.70	847	967	313	654	-99.0	50.0
11	34.12	-108.54	36.91	-112.27	39.57	-116.27	48.52	925	12	11	1	8.0	44.0
12	17.20	-78.33	12.75	-77.44	8.29	-76.59	190.76	999	12	12	0	16.0	37.0
13	36.11	-139.51	40.67	-140.40	45.23	-141.41	8.92	1035	170	146	24	-12.0	41.0
14	39.57	-116.27	35.39	-118.91	31.15	-121.29	154.19	1069	145	136	9	-17.0	41.0
15	50.25	4.49	51.68	-3.12	52.59	-11.13	76.37	1139	246	42	204	-99.0	39.0
16	34.12	-108.54	32.80	-115.02	31.15	-121.29	105.53	1221	108	105	3	-8.0	41.0
17	-17.19	-123.39	-20.33	-128.30	-23.32	-133.41	123.19	1253	154	140	14	-12.0	47.0
18	19.11	-72.49	13.71	-74.59	8.29	-76.59	159.86	1272	2	2	0	27.0	34.0
19	52.42	8.54	52.91	-1.28	52.59	-11.13	89.17	1347	312	305	7	-35.0	43.0
20	61.28	-21.52	56.38	-13.38	51.07	-7.16	217.26	1455	39	39	0	-17.0	40.0
21	36.42	-3.11	43.76	-4.89	51.07	-7.16	11.06	1635	4	4	0	28.0	58.0
22	7.06	-79.54	14.70	-83.71	22.27	-88.18	28.59	1930	6	6	0	.1	35.0
23	20.36	-58.53	24.68	-67.53	28.43	-77.12	64.31	2056	35	26	9	7.0	34.0
24	39.54	-30.42	43.62	-19.18	46.46	-6.57	292.07	2057	6	6	0	15.0	44.0
25	40.58	-24.21	46.61	-13.04	51.31	.57	302.76	2255	2	1	1	15.0	37.0
26	20.36	-58.53	14.50	-67.81	8.29	-76.59	124.85	2365	8	8	0	21.0	28.0
27	39.54	-30.42	45.72	-18.28	50.33	-3.56	300.45	2389	8	8	0	10.0	43.0
28	7.06	-79.54	17.75	-78.40	28.43	-77.12	353.94	2420	3	3	0	8.0	23.0
29	16.37	-120.17	27.98	-118.43	39.57	-116.27	351.77	2621	11	11	0	20.0	39.0
30	15.21	-120.37	27.40	-118.55	39.57	-116.27	351.73	2765	53	51	2	-1.0	33.0
31	-4.36	-55.28	2.00	-65.89	8.29	-76.59	59.04	2795	12	12	0	8.0	28.0
32	1.25	-103.44	11.86	-96.11	22.27	-88.18	325.03	2873	5	5	0	25.0	33.0
33	1.25	-103.44	4.90	-90.09	8.29	-76.59	284.89	3064	14	14	0	22.0	33.0
34	32.04	-34.47	43.00	-19.68	51.31	.57	308.31	3611	10	10	0	18.0	44.0
35	35.41	-51.27	45.75	-34.25	52.59	-11.13	302.84	3665	89	71	18	-33.0	46.0
36	35.41	-51.27	45.38	-32.21	51.07	-7.16	297.97	3886	106	104	2	-13.0	38.0
37	35.41	-51.27	46.50	-32.76	53.34	-7.07	302.02	3945	488	385	103	-47.0	41.0
38	1.25	-103.44	15.22	-91.14	28.43	-77.12	317.86	4139	23	22	1	1.0	33.0
39	1.25	-103.44	20.53	-109.02	39.57	-116.27	16.49	4474	65	65	0	-2.0	31.0
40	45.53	64.19	53.37	34.45	52.00	.08	79.83	4582	1	0	1	1.0	3.0

Path Information for the PROPHET Field Strength Database (cont)

ID	TRANSMTR LATITUDE	TRANSMTR LONGITUD	MID PATH LATITUDE	MID PATH LONGITUD	RECEIVER LATITUDE	RECEIVER LONGITUD	AZIMUTH	CKT LENGTH	HOURS TOTAL	HOURS BELOW	HOURS ABOVE	MIN VALUE	MAX VALUE
41	29.16	-47.53	42.74	-27.71	51.31	.57	303.99	4700	1	1	0	10.0	34.0
42	-7.54	14.23	-17.91	[illegible]	-26.06	-27.55	115.72	4902	24	24	0	8.0	43.0
43	45.53	64.19	54.08	30.75	51.07	-7.16	81.92	5095	16	7	9	-6.0	33.0
44	45.53	64.19	51.78	29.15	46.46	-6.57	88.70	5277	3	1	2	3.0	39.0
45	41.42	70.00	54.14	36.63	53.34	-7.07	73.78	5632	756	646	110	-75.0	38.0
46	45.53	64.19	61.39	29.22	60.34	-25.00	68.00	5671	4	3	1	-20.0	.0
47	22.00	159.48	32.74	-172.75	36.22	-140.38	286.57	5906	710	663	47	-14.0	28.0
48	41.42	70.00	54.58	34.57	52.59	-11.13	75.24	5910	166	137	29	-78.0	24.0
49	-12.25	-130.37	13.76	-124.16	39.57	-116.27	346.40	6004	1	1	0	10.0	25.0
50	35.35	77.22	50.51	45.01	52.00	.08	69.25	6150	1	1	0	13.0	17.0
51	35.35	77.22	50.45	42.75	50.33	-3.56	71.99	6468	3	2	1	-2.0	25.0
52	-1.21	-36.54	26.21	-26.98	52.59	-11.13	339.94	6497	435	404	31	-46.0	42.0
53	36.48	76.30	53.46	40.17	52.59	-11.13	70.51	6690	655	578	77	-91.0	32.0
54	52.15	1.08	47.23	-46.25	28.43	-77.12	117.10	6756	7	7	0	8.0	19.0
55	34.43	-33.19	4.19	-30.25	-26.06	-27.55	184.80	6787	8	8	0	1.0	50.0
56	35.35	77.22	49.25	39.65	46.46	-6.57	77.30	6825	2	1	1	13.0	25.0
57	17.06	61.48	39.03	35.20	51.07	-7.16	53.62	7082	23	23	0	19.0	30.0
58	-24.54	-113.43	2.05	-95.59	28.43	-77.12	328.00	7126	18	18	0	10.0	32.0
59	-24.54	-113.43	7.52	-114.73	39.57	-116.27	2.23	7217	14	14	0	9.0	27.0
60	35.35	77.22	59.29	42.99	60.34	-25.00	58.21	7238	2	2	0	-11.0	17.0
61	48.05	-10.41	57.74	-68.72	39.57	-116.27	99.97	7807	14	7	7	-30.0	25.0
62	-7.54	14.23	27.62	1.40	60.34	-25.00	21.30	8355	3	3	0	10.0	32.0
63	-36.20	-145.25	-16.71	-106.95	8.29	-76.59	307.49	8689	13	13	0	6.0	24.0
64	-26.35	-28.08	12.56	-19.48	51.07	-7.16	347.91	8879	14	14	0	.0	21.0
65	-36.20	-145.25	1.74	-131.10	39.57	-116.27	342.19	8985	8	8	0	17.0	34.0
66	35.46	-139.37	66.38	-92.43	53.34	-7.07	294.97	9083	945	513	432	-99.0	20.0
67	40.42	105.02	55.62	-195.10	36.22	-140.38	265.58	9144	307	248	59	-25.0	16.0
68	52.15	1.08	13.43	-15.99	-26.06	-27.55	164.09	9159	3	3	0	3.0	37.0
69	-26.35	-28.08	13.19	-16.66	52.00	.08	344.34	9163	1	1	0	2.0	12.0
70	-20.19	-57.31	17.46	-39.44	52.59	-11.13	334.25	9287	717	713	4	-67.0	34.0
71	54.44	2.54	14.65	-15.80	-26.06	-27.55	164.22	9459	4	4	0	-1.0	19.0
72	-.14	78.20	31.32	48.14	50.33	-3.56	47.94	9483	4	4	0	.1	27.0
73	-.14	78.20	32.37	47.40	51.07	-7.16	47.94	9721	15	15	0	-6.0	39.0
74	35.45	119.17	58.75	-181.56	39.57	-116.27	274.49	9849	17	13	4	-18.0	18.0
75	-36.20	-145.25	-4.68	-109.52	28.43	-77.12	318.63	10151	15	15	0	.0	16.0
76	-.14	78.20	40.64	49.69	60.34	-25.00	39.73	10754	2	2	0	4.0	26.0
77	39.00	76.48	67.66	-208.74	36.22	-140.38	266.14	10798	48	30	18	-41.0	1.0
78	-12.25	-130.37	34.07	-100.95	60.34	-25.00	323.66	12059	6	5	1	-99.0	29.0
79	-24.54	-113.43	23.42	-85.25	60.34	-25.00	328.45	12332	6	6	0	-27.0	9.0
80	-35.18	-149.12	21.74	-101.11	52.59	-11.13	320.53	16206	822	704	118	-99.0	22.0
81	-35.18	-149.12	24.12	-102.46	53.34	-7.07	321.79	16448	169	156	13	-99.0	15.0

Field Strength Database Description

ID	TRANSMITTER	RECEIVER	TLAT	TLON	MLAT	RLAT	RLON	AZIM	RANGE	HOURS	FREQUENCIES (MHz)
1	LUXEMBURG	BOCKHACKEN	49.4	-6.2	50.2	51.1	-7.2	20.3	175	54	6.1
2	SANWA	AKITA	36.1	-139.5	37.8	39.4	-140.1	7.8	396	380	5.0
3	KOGANEI	AKITA	35.4	-139.3	37.4	39.4	-140.1	8.6	454	960	5.0
4	KURSEONG	CALCUTTA	26.5	-88.2	24.4	22.3	-88.2	179.8	497	4	7.2
5	BRACKNELL	NORDDEICH	52.0	1.1	52.8	53.3	-7.1	75.2	585	1169	4.8, 8.0,11.1,14.4,18.3
6	BRACKNELL	BOCKHACKEN	52.0	1.1	51.6	51.1	-7.2	100.6	595	50	8.0
7	ALLOUIS	BOCKHACKEN	47.0	-2.0	49.1	51.1	-7.2	39.7	597	58	6.2
8	OSLO	NORDDEICH	59.3	-10.4	56.3	53.3	-7.1	197.0	686	415	6.4,12.7,17.1,22.4
9	OSLO	LUECHOW	59.3	-10.4	55.9	52.6	-11.1	176.3	718	89	6.4,12.9,16.9,22.4
10	BRACKNELL	LUECHOW	52.0	1.1	52.5	52.6	-11.1	85.7	847	967	4.8, 8.0, 9.2,11.1,14.4,18.3
11	XIAN	BEIJING	34.1	-108.5	36.9	39.6	-116.3	48.5	925	12	7.3
12	HYDERABAD	TRIVANDRUM	17.2	-78.3	12.7	8.3	-76.6	190.8	999	12	4.8
13	SANWA	WAKKANAI	36.1	-139.5	40.7	45.2	-141.4	8.9	1035	170	5.0, 8.0
14	BEIJING	SHANGHAI	39.6	-116.3	35.4	31.1	-121.3	154.2	1069	145	4.8,5.0,6.2,7.3,9.7,11.7,12.0
15	PLYMOUTH	LUECHOW	50.2	4.5	51.7	52.6	-11.1	76.4	1139	246	6.4,12.8,16.9,22.4
16	XIAN	SHANGHAI	34.1	-108.5	32.8	31.1	-121.3	105.5	1221	108	7.1, 7.3,11.7,15.3
17	DERBY	ALICE SPR.	-17.2	-123.4	-20.3	-23.3	-133.4	123.2	1253	154	6.8,13.6
18	BOMBAY	TRIVANDRUM	19.1	-72.5	13.7	8.3	-76.6	159.9	1272	2	11.8
19	SHANNON	LUECHOW	52.4	8.5	52.9	52.6	-11.1	89.2	1347	312	5.5
20	PORI	BOCKHACKEN	61.3	-21.5	56.4	51.1	-7.2	217.3	1455	39	6.1
21	ALGER	BOCKHACKEN	36.4	-3.1	43.8	51.1	-7.2	11.1	1635	4	7.2
22	EKALA	CALCUTTA	7.1	-79.5	14.7	22.3	-88.2	28.6	1930	6	11.8
23	MASIRAH	DELHI	20.4	-58.5	24.7	28.4	-77.1	64.3	2056	35	12.0,15.3,17.8
24	ANKARA	CHATTONAYE	39.5	-30.4	43.6	46.5	-6.6	292.1	2057	6	15.2
25	KAVALLA	CROWSLEY PK	40.6	-24.2	46.6	51.3	.6	302.8	2255	2	11.7
26	MASIRAH	TRIVANDRUM	20.4	-58.5	14.5	8.3	-76.6	124.8	2365	8	12.0,15.3
27	ANKARA	JURBISE	39.5	-30.4	45.7	50.3	-3.6	300.5	2389	8	15.2
28	EKALA	DELHI	7.1	-79.5	17.7	28.4	-77.1	353.9	2420	3	15.1
29	PORO	BEIJING	16.4	-120.2	28.0	39.6	-116.3	351.8	2621	11	9.6,17.8
30	TINANG	BEIJING	15.2	-120.4	27.4	39.6	-116.3	351.7	2765	53	9.6,11.7,12.0,15.4
31	MAHE	TRIVANDRUM	-4.4	-55.3	2.0	8.3	-76.6	59.0	2795	12	15.3
32	KRANJI	CALCUTTA	1.2	-103.4	11.9	22.3	-88.2	325.0	2873	5	9.7,11.7
33	KRANJI	TRIVANDRUM	1.2	-103.4	4.9	8.3	-76.6	284.9	3064	14	9.7
34	JERUSALEM	CROWSLEY PK	32.0	-34.5	43.0	51.3	.6	308.3	3611	10	9.4
35	TEHERAN	LUECHOW	35.4	-51.3	45.8	52.6	-11.1	302.8	3665	89	15.1
36	TEHERAN	BOCKHACKEN	35.4	-51.3	45.4	51.1	-7.2	298.0	3886	106	9.0,15.1
37	TEHERAN	NORDDEICH	35.4	-51.3	46.5	53.3	-7.1	302.0	3945	488	9.0,15.1
38	KRANJI	DELHI	1.2	-103.4	15.2	28.4	-77.1	317.9	4139	23	9.7,12.0,15.4
39	KRANJI	BEIJING	1.2	-103.4	20.5	39.6	-116.3	16.5	4474	65	6.2, 9.7,12.0,15.4
40	SACKVILLE	BALDOCK	45.5	64.2	53.4	52.0	.1	79.8	4582	1	17.9

FIELD STRENGTH DATA BASE DESCRIPTION (cont)

ID	TRANSMITTER	RECEIVER	TLAT	TLON	MLAT	RLAT	RLON	AZIM	RANGE	HOURS	FREQUENCIES (MHz)
41	KUWAIT	CROWSLEY PK	29.2	-47.5	42.7	51.3	.6	304.0	4700	1	21.7
42	ASCENSION	PANORAMA	-7.5	14.2	-17.9	-26.1	-27.5	115.7	4902	24	6.0, 9.7,15.4,21.7
43	SACKVILLE	BOCKHACKEN	45.5	64.2	54.1	51.1	-7.2	81.9	5095	16	15.3,21.7
44	SACKVILLE	CHATTONAYE	45.5	64.2	51.8	46.5	-6.6	88.7	5277	3	15.3
45	NEW YORK	NORDDEICH	41.4	70.0	54.1	53.3	-7.1	73.8	5632	756	6.4, 8.6,13.0,17.0,22.5
46	SACKVILLE	JOKELA	45.5	64.2	61.4	60.3	-25.0	68.0	5671	4	15.3,17.8
47	KAUAI	HIRAISO	22.0	159.5	32.7	36.2	-140.4	286.6	5906	710	15.0
48	NEW YORK	LUECHOW	41.4	70.0	54.6	52.6	-11.1	75.2	5910	166	6.4, 8.6,13.0,17.0,22.5
49	DARWIN	BEIJING	-12.2	-130.4	13.8	39.6	-116.3	346.4	6004	1	7.1
50	GREENVILLE	BALDOCK	35.3	77.2	50.5	52.0	.1	69.2	6150	1	9.7
51	GREENVILLE	JURBISE	35.3	77.2	50.5	50.3	-3.6	72.0	6468	3	15.4
52	NAIROBI	LUECHOW	-1.2	-36.5	26.2	52.6	-11.1	339.9	6497	435	9.0,17.4
53	NORFOLK	LUECHOW	36.5	76.3	53.5	52.6	-11.1	70.5	6690	655	5.0, 8.1,10.9,16.4,20.0
54	DAVENTRY	DELHI	52.2	1.1	47.2	28.4	-77.1	117.1	6756	7	17.7,17.8
55	LIMASSOL	PANORAMA	34.4	-33.2	4.2	-26.1	-27.5	184.8	6787	8	17.9,21.7
56	GREENVILLE	CHATTONAYE	35.3	77.2	49.2	46.5	-6.6	77.3	6825	2	9.7
57	ANTIGUA	BOCKHACKEN	17.1	61.5	39.0	51.1	-7.2	53.6	7082	23	6.2
58	CARNARVON	DELHI	-24.5	-113.4	2.0	28.4	-77.1	328.0	7126	18	9.8,21.6,21.7
59	CARNARVON	BEIJING	-24.5	-113.4	7.5	39.6	-116.3	2.2	7217	14	11.8
60	GREENVILLE	JOKELA	35.3	77.2	59.3	60.3	-25.0	58.2	7238	2	9.7
61	WERTACHTAL	BEIJING	48.0	-10.4	57.7	39.6	-116.3	100.0	7807	14	11.8,15.3,17.8,21.6
62	ASCENSION	JOKELA	-7.5	14.2	27.6	60.3	-25.0	21.3	8355	3	9.7,11.8
63	SHEPPARTON	TRIVANDRUM	-36.2	-145.3	-16.7	8.3	-76.6	307.5	8689	13	9.8
64	MEYERTON	BOCKHACKEN	-26.4	-28.1	12.6	51.1	-7.2	347.9	8879	14	21.5,25.8
65	SHEPPARTON	BEIJING	-36.2	-145.3	1.7	39.6	-116.3	342.2	8985	8	15.1
66	TOKYO	NORDDEICH	35.5	-139.4	66.4	53.3	-7.1	295.0	9083	945	7.3,10.0,13.6,18.2,22.8
67	FORT COLLINS	HIRAISO	40.4	105.0	55.6	36.2	-140.4	265.6	9144	307	15.0
68	DAVENTRY	PANORAMA	52.2	1.1	13.4	-26.1	-27.5	164.1	9159	3	21.7
69	MEYERTON	BALDOCK	-26.4	-28.1	13.2	52.0	.1	344.3	9163	1	25.8
70	MAURITIUS	LUECHOW	-20.2	-57.3	17.5	52.6	-11.1	334.3	9287	717	8.6,13.0,17.0,22.6
71	SKELTON	PANORAMA	54.4	2.5	14.6	-26.1	-27.5	164.2	9459	4	21.7
72	QUITO	JURBISE	-.1	78.2	31.3	50.3	-3.6	47.9	9483	4	11.8
73	QUITO	BOCKHACKEN	-.1	78.2	32.4	51.1	-7.2	47.9	9721	15	9.7
74	DELANO	BEIJING	35.5	119.2	58.8	39.6	-116.3	274.5	9849	17	21.5
75	SHEPPARTON	DELHI	-36.2	-145.3	-4.7	28.4	-77.1	318.6	10151	15	21.7
76	QUITO	JOKELA	-.1	78.2	40.6	60.3	-25.0	39.7	10754	2	11.8
77	WASHINGTON	HIRAISO	39.0	76.5	67.7	36.2	-140.4	266.1	10798	48	15.0
78	DARWIN	JOKELA	-12.2	-130.4	34.1	60.3	-25.0	323.7	12059	6	7.1,21.7
79	CARNARVON	JOKELA	-24.5	-113.4	23.4	60.3	-25.0	328.5	12332	6	15.4,17.7
80	CANBERRA	LUECHOW	-35.2	-149.1	21.7	52.6	-11.1	320.5	16206	822	5.1,11.0,13.9,19.7
81	CANBERRA	NORDDEICH	-35.2	-149.1	24.1	53.3	-7.1	321.8	16448	169	5.1,11.0,13.9,19.7

APPENDIX C
DATA MERGE PROGRAM

Feb 07 21:09 1988 mrgfs.f

```
      program mrgfs
c
c  This program merges Field Strength data generated by the TDA program
c  FSTREN into the field strength CCIR database 'fsdb.hfbc', based on the
c  universal time, frequency and SSN, as indexed by control file 'fsccir4'
c  and saves the final merged output into 'merg.hfbc'
c
      implicit none
      integer idummy
c
c fsccir4 declarations                          (note: ut: range=1-24)
      real ut,month,year,mmssn,pathln,rlat,rlon,midpt,tlat,tlon,
     *   dummy,opfreq,ofqluf,lufmuf,fs,ofqomf,rmssn,luf,ofqmuf,opmuf
      integer pathid,rec4
c
c  fsdb.hfbc header declarations
      integer is,nflds,nrecs,recdb
      character*60 dbname
      character*80 fmt
c
c  fsdb.hfbc data record declarations
      real mlat,lt,fmuf,obs,pred1,sssn
      integer id,len,sea,ort,ssn
c
c  tstnew (predicted model) declarations       (note: lmt: range=0-23)
      integer ssnp,monp,yearp,loop,itp,recp
      real mmssnp,lmt,fst,frq,luf2,muf2,omuf2,utp,fst0
c
c  merg.hfbc declarations
      integer recm
      character*80 fmtnew
      data fmtnew
     *   /'(i2,i6,2i2,i4,f7.1,f5.1,f4.1,2f6.1 ,i3,f5.1,i3,i5,2f6.1)'/
c
c  initialize counters
      rec4=0
      recdb=0
      recp=0
c
c  open all files used by this program
      open(10,file='fsdb.hfbc',status='old',err=9100)
      open(11,file='tstnew'   ,status='old',err=9110)
      open(12,file='fsccir4'  ,status='old',err=9120)
      open(13,file='merg.hfbc',status='new',err=9130)
      write(*,986)
986   format(' files opened')
c
```

```
c  copy over database header
        read(10,80,err=9100) is,nflds,nrecs,dbname,fmt
80      format(2i5,i8,2x,a/a)
        write(*,984)
984     format(' header read')
        write(13,80) id,nflds,nrecs,dbname,fmtnew
        recm=1
        write(*,988)
988     format(' header written')
c
c  read in initial observed database record
        read(12,110,err=9120,end=9120) ut,month,year,mmssn,pathln,
     *    rlat,rlon,midpt,tlat,tlon,dummy,opfreq,ofqluf,lufmuf,fs,
     *     ofqomf,rmssn,luf,ofqmuf,opmuf,pathid
        rec4=3
110     format(2(7f10.0,/),6f10.0,7x,i3)
        read(10,fmt,err=9100,end=9100) id,len,sea,ort,ssn,mlat,lt,
     *    fmuf,obs,pred1
        recdb=2
        sssn=ssn
        write(*,989)
989     format(' initial db record read in')
c
c  make sure field strength databases are in sync...
        if (rmssn.ne.sssn.or.fs.ne.obs.or.pathid.ne.id) then
                write(*,140) rec4,recdb
140             format(' mismatch at ccir4 db (',i4,') and hfbc (',
     *            i4,')')
                endif
c
c  read in values from predicted model run
145     read(11,150,err=9110,end=5000) ssnp,monp,yearp,dummy
150     format(39x,i3,5x,i2,1x,i4/12x,f8.0)
        recp=recp+1
        mmssnp=ssnp
c
c  loop through all 24 entries searching for a Universal Time match
c  (note that for loop=0, utp=0, but fsccir4 doesn't have ut=0, but instead
c   has ut=24...therefore, on loop # '0', save fs, and for loop # '24' use
c   that value as if utp=24!  If you thought that was complicated,
c   you should see how long it took to figure this out!!)
        do 300 loop=0,24
        if (loop.eq.24) then
                utp=24.0
                fst=fst0
        else
                read(11,160,err=9110,end=9110) itp,lmt,fst,frq,
     *            luf2,muf2,omuf2
160             format(i10,6f10.5)
                recp=recp+1
                utp=itp
                if (itp.eq.0) fst0=fst
                endif
c
```

```
c  check for a match to the fs database
          if (utp.eq.ut.and.frq.eq.opfreq.and.mmssnp.eq.mmssn) then
c
c  found a match - create updated entry in merged database
                    write(13,fmtnew)id,len,sea,ort,ssn,mlat,lt,fmuf,obs,
     *                fst,utp,opfreq,month,year,ofqmuf,mmssn
                    recm=recm+1
c
c  read in next database entry
                    read(12,110,err=9120,end=5000) ut,month,year,mmssn,
     *                pathln,rlat,rlon,midpt,tlat,tlon,dummy,opfreq,ofqluf,

     *                lufmuf,fs,ofqomf,rmssn,luf,ofqmuf,opmuf,pathid
                    rec4=rec4+3
                    read(10,fmt,err=9100,end=5000) id,len,sea,ort,ssn,mlat,
     *                lt,fmuf,obs,pred1
                    recdb=recdb+1
                    sssn=ssn
                    idummy=mod(recdb,100)
                    if (idummy.eq.0) write(*,987) recdb,rec4
987       format(' recdb=',i6,' (12279), rec4=',i6,' (36831), ')
c
c  are field strength databases still in sync?....
                    if (rmssn.ne.sssn.or.fs.ne.obs.or.pathid.ne.id) then
                            write(*,140) rec4,recdb
                            endif
                    endif
300       continue
c
c  all entries from current configuration of predicted model are
c  complete - go read in another predicted model data set
          go to 145
c
c  eof encountered on any of the input files has occured
5000      write(*,5010) recdb,recp,rec4,recm
5010      format(1x,i5,' recs read from fsdb.hfbc'/
     *           1x,i5,' recs read from tstnew'/
     *           1x,i5,' recs read from fsccir4'/
     *           1x,i5,' recs written to merg.hfbc')
          close(10)
          close(11)
          close(12)
          close(13)
          go to 9900
c
c  disk errors
9100      write(*,9105)
9105      format(' disk error on fsdb.hfbc'/)
          go to 5000
c
9110      write(*,9115)
9115      format(' disk error on tstnew'/)
          go to 5000
c
```

```
9120    write(*,9125)
9125    format(' disk error on fsccir4'/)
        go to 5000
c
9130    write(*,9135)
9135    format(' disk error on merg.hfbc'/)
        go to 5000
c
9900    end
```

APPENDIX D

Statistical Table
Generation Program

```
      program mtabl
c
c  This program reads thru a "DSOxx" statistical output file generated
by
c  the TURBO program and creates an ascii table for use ~~in~~ subsequent
c  report generations.  Two input lines are required:
c      "DSOxx" filename (80 char) and output 'table' filename (80 chars)
c  The output file (table) is in the same format as that generated in
the
c  original 1984 report.  The LTLFLD columns are filled in by reads to
the
c  "DSOxx" file located in you current directory and the DAMBLT columns
are
c  filled in by reads to the "DSOxx" file located in the original field
c  strength directory '/bigdisk/datscr/fldstr/results/"DSOxx"'.
c
      implicit none

      real totpop
      parameter (totpop=12277.0)

      integer ncmax
      parameter (ncmax=8)

      integer mxline
      parameter (mxline=30)

      integer ncvar(ncmax),popsz,idummy(10),i,nconds,line
      integer zcvar(ncmax),zopsz
      character*1 rangesep
      character*2 codes(ncmax),zodes(ncmax),ch
      real cval(ncmax),AvgRes,RmsRes,dummy,AvgRelRs,RmsRelRs,AvAbRlRs
      real zval(ncmax),zvgres,zmsres,       zvgrelrs,zmsrelrs,zvabrlrs
      real dummy3(3),Corr,PcPop,zorr,zcpop
      character*65 infyl,oufyl,apfyl
      character*31 apbeg
      data apbeg/'/bigdisk/datscr/fldstr/results/'/

      write(6,140)
140   format(' Enter input filename  <rtn>  output (table) filename')
      read(5,160,err=900) infyl,oufyl
160   format(a/a)

      apfyl=apbeg // infyl
      write(6,200) infyl,oufyl,apfyl
200   format(' Stat file  (input)  is :',A /
     *         ' Table file (output) is :',A /
     *           ' APES (NOSC) file  is :',A)
c
c  open all used files
      open(10,file=infyl,status='old',err=9100)
      open(11,file=oufyl,status='new',err=9110)
      open(12,file=apfyl,status='old',err=9120)
      line=mxline
c
c  read in a logical data 'record' (5 physical records) from "DSOxx"
file
300   read(10,340,err=9100,end=800) (ncvar(i),codes(i),cval(i),i=1,8)
```

```
340   format(8(i2,a2,f10.2,1x))

      read(10,380,e r=9100) AvgRes,RmsRes,dummy,AvgRelRs,RmsRelRs,
     *    dummy,     AvAbRlRs,dummy3,Corr,popsz,     dummy3,dummy3,
     *    dummy3,idummy
380   format(6g10.4e2/5g10.4e2,i10/6g10.4e2/2g10.4e2,f6.3,i6,i4,8i2)
c
c  count number of conditions satisfied to determine printout format
      nconds=0
      do i=ncmax,1,-1
      if (codes(i).ne.'  ') then
            nconds=i
            go to 460
            endif
      enddo
c
c  read in a logical data 'record' from original APES NOSC file
460   read(12,340,err=9120) (zcvar(i),zodes(i),zval(i),i=1,8)
      read(12,380,err=9120) zvgres,zmsres,dummy,zvgrelrs,zmsrelrs,
     *    dummy,zvabrlrs,dummy3,zorr,zopsz,dummy3,dummy3,
     *    dummy3,idummy
c
c  calculate percent of total population
      dummy=popsz
      PcPop=(dummy/totpop)*100.0

      dummy=zopsz
      zcpop=(dummy/totpop)*100.0

      line=line+1

      if (line.le.mxline) go to 540
c
c  write out table header first
      write(11,500,err=9110)
500   format(1h1/2x,'Conditions',4x,'Avg Residual',5x,'Rms Residual',
     *    5x,'Avg Rel Res ',5x,'Rms Rel Res ',3x,'Avg Abs Rel Res ',
     *    2x,'Correlation ',3x,'% of Total'
     *    / 11x, 5(4x,'LtFld',3x,'DmBlt'), 2(4x,'LFld',3x,'DBlt')
     *    / 128('=') )
      line=1
c
c  determine table printout format
c
c              None   Single  Multiple
540   go to ( 580,    660,     740    ) nconds+1
      if (nconds.gt.0) go to 740
c
c  no conditions found  (assume OverAll run)
580   write(11,620,err=9110) AvgRes,zvgres,RmsRes,zmsres,AvgRelRs,
     *    zvgrelrs,RmsRelRs,zmsrelrs,AvAbRlRs,zvabrlrs,Corr,zorr,
     *    PcPop,zcpop
620   format(12x,5(' | ',f5.1,' / ',f5.1,1x),
     *    ' | ',f4.2,' / ',f4.2,1x,' | ',f4.1,' / ',f4.1)
      go to 300
c
c  one condition found - just print it out
660   ch='= '
```

```
      if (codes(nconds).eq.'LT') ch='< '
      if (codes(nconds).eq.'LE') ch='<='
      if (codes(nconds).eq.'GT') ch='> '
      if (codes(nconds).eq.'GE') ch='>='
      if (codes(nconds).eq.'NE') ch='<>'
      write(11,700,err=9110) ch,cval(nconds),AvgRes,zvgres,RmsRes,
     *    zmsres,AvgRelRs,zvgrelrs,RmsRelRs,zmsrelrs,AvAbRlRs,
     *    zvabrlrs,Corr,zorr,PcPop,zcpop
700   format(1x,a2,1x,f8.2,5(' | ',f5.1,' / ',f5.1,1x),
     *    ' | ',f4.2,' / ',f4.2,1x,' | ',f4.1,' / ',f4.1)
      go to 300
c
c  multiple conditions found - - assume last two are to be printed
740   if (codes(nconds).eq.'EQ') go to 660
      rangesep='-'
      if (cval(nconds-1).ge.1000.0.or.cval(nconds).ge.1000.0) then
          cval(nconds-1)=cval(nconds-1)/1000.0
          cval(nconds)=cval(nconds)/1000.0
          rangesep='='
          endif
      write(11,780,err=9110) cval(nconds-1),rangesep,cval(nconds),
     *    AvgRes,zvgres,RmsRes,zmsres,AvgRelRs,zvgrelrs,RmsRelRs,
     *    zmsrelrs,AvAbRlRs,zvabrlrs,Corr,zorr,PcPop,zcpop
780   format(1x,f5.1,a1,f5.1,5(' | ',f5.1,' / ',f5.1,1x),
     *    ' | ',f4.2,' / ',f4.2,1x,' | ',f4.1,' / ',f4.1)
      go to 300
c
c  EOF on data
800   write(11,820)
820   format(1h1)
      go to 9900
c
c  error on command input
900   write(6,910)
910   format(' Error reading commands (filenames)')
      go to 9900
c
c  error on input (DSOxx) file
9100  write(6,9105) infyl
9105  format(' Error reading data from DSOxx file ',A)
      go to 9900
c
c  error on output (table) file
9110  write(6,9115) oufyl
9115  format(' Error writing to table file ',A)
      go to 9900
c
c  error on orig APES NOSC file
9120  write(6,9125) apfyl
9125  format(' Error reading data from orig. NOSC "DSOxx" file ',a)
c
c  close all files and exit
9900  close(10)
      close(11)
      end
```

APPENDIX E

Field Strength Test Results

Conditions	Avg Residual		Rms Residual		Avg Rel Res		Rms Rel Res		Avg Abs Rel Res		Correlation		% of Total	
f/inUF	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LFld	DBlt	LFld	DBlt
overall	.0	4.7	14.2	23.1	.1	1.1	19.7	35.0	2.1	3.0	.70	.60	100.	100.
<= 1.00	-1.1	1.5	13.5	16.5	-.5	.3	19.4	27.4	2.0	2.7	.69	.65	70.3	71.1
> 1.00	2.7	12.6	15.8	34.5	1.7	3.0	20.5	48.9	2.5	3.9	.60	.48	29.7	28.9

Table E-1. Summary of Overall results for entire data base

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
<= .20	37.7	55.1	44.3	63.6	-1.6	8.5	2.2	71.2	-1.6	8.6	.90	.88	.1	.3
= .30	6.1	15.5	21.4	31.6	-2.4	7.8	17.2	85.2	1.6	10.6	.64	.67	2.3	2.5
= .40	.3	6.2	11.5	17.7	.0	.3	16.2	19.9	1.7	1.7	.76	.76	9.6	9.4
= .50	2.1	3.6	11.1	13.5	.0	.3	17.2	22.5	2.6	2.9	.74	.75	12.3	12.4
= .60	1.9	2.9	11.8	13.1	1.2	1.7	29.3	32.9	2.3	3.3	.71	.73	11.7	11.9
= .70	-.4	1.0	12.2	13.4	-.9	-.3	14.7	15.7	1.5	2.0	.72	.69	10.5	10.6
= .80	-3.5	-2.5	14.1	15.6	-1.1	-1.3	18.0	21.9	2.0	2.8	.67	.60	9.8	9.9
= .90	-6.9	-4.7	15.6	16.4	-2.1	-1.6	18.0	17.5	2.2	2.0	.74	.66	7.7	7.7
= 1.00	-8.3	-5.5	16.7	17.4	-1.2	-.1	15.8	12.2	1.5	1.1	.73	.66	6.4	6.4
= 1.10	-6.4	-5.0	16.3	17.4	-1.8	-1.8	20.3	19.9	2.0	2.4	.70	.63	5.0	5.0
= 1.20	-4.7	-6.2	16.0	16.4	-.4	.1	13.3	9.8	.9	.4	.67	.66	4.1	3.9
= 1.30	-.8	-6.5	17.0	17.9	.2	-.8	12.3	14.6	1.4	1.1	.51	.50	2.9	2.8
= 1.40	4.2	-5.1	17.9	16.6	.9	.4	2.4	6.8	.5	.3	.37	.50	2.0	1.9
= 1.50	1.0	-4.7	15.3	16.8	1.2	.1	4.8	7.4	.6	.5	.48	.35	2.3	2.2
= 1.60	5.8	1.1	17.0	14.0	1.4	1.5	3.6	6.9	1.0	.7	.35	.43	1.6	1.5
= 1.70	6.9	3.5	14.3	12.7	2.9	2.1	14.2	10.9	2.7	1.7	.51	.48	1.3	1.2
= 1.80	5.0	4.9	14.9	13.5	4.4	3.4	17.4	14.5	4.0	3.0	.31	.16	1.1	1.0
= 1.90	5.9	9.0	12.6	15.0	3.9	6.6	18.6	28.4	3.7	6.4	.48	.09	.9	1.0
= 2.00	7.8	14.9	13.7	19.9	3.6	10.7	18.4	48.1	3.4	10.7	.50	.06	1.1	1.0
2.0- 2.5	8.5	31.6	13.4	34.8	6.4	14.0	30.9	81.8	6.4	14.0	.36	.18	3.2	3.1
2.5- 3.0	11.3	66.7	14.6	68.5	4.5	14.9	29.9	120.2	4.5	14.9	.26	.12	1.8	1.7
3.0- 3.5	14.1	83.1	16.1	83.5	8.4	10.1	50.2	131.3	8.4	10.1	.43	.09	1.0	1.0
3.5- 4.0	15.5	82.3	17.4	82.6	3.5	-7.4	34.3	14.1	3.5	-7.4	.18	.00	.7	.7
4.0- 4.5	17.5	80.3	18.7	80.5	-1.1	-5.0	6.9	5.6	-1.1	-5.0	.18	.00	.4	.4
4.5- 5.0	16.0	75.9	17.1	76.2	-.8	-3.8	1.0	4.1	-.8	-3.8	.64	.00	.2	.2
> 5.00	16.4	73.8	17.2	73.9	-.7	-3.1	.8	3.3	-.7	-3.1	.18	.00	.2	.2

Table E-2. Summary of results as a function of Frequency to MUF ratio for the entire data base

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
1.00	5.2	13.6	13.4	15.7	.1	.4	.5	.5	.3	.5	.11	.15	.4	.4
2.00	-8.8	-7.9	10.6	10.0	-2.4	-2.4	14.0	14.7	2.4	2.4	.82	.84	3.1	3.1
3.00	-2.2	.9	8.2	8.3	-.2	.0	.6	.5	.3	.3	.63	.69	7.8	7.8
4.00	4.2	2.0	5.1	3.2	.1	.1	.2	.1	.1	.1	-.33	-.32	.0	.0
5.00	6.7	23.5	13.9	38.3	1.7	4.7	24.5	66.0	3.1	5.6	.84	.78	9.5	9.5
6.00	4.0	8.7	13.4	13.4	2.7	4.0	17.6	22.0	4.3	5.0	.56	.59	.4	.4
7.00	15.0	22.9	19.6	23.8	.4	.6	.5	.6	.4	.6	-.01	.40	.5	.5
8.00	6.4	20.9	14.0	37.7	3.5	6.5	21.6	61.3	3.0	6.3	.79	.69	3.4	3.4
9.00	-3.3	1.6	19.2	32.5	1.6	1.5	3.2	5.1	-.8	-1.5	.39	.39	.7	.7
10.00	4.5	19.8	13.3	34.7	1.8	2.9	22.9	40.9	3.4	4.1	.81	.78	7.9	7.9
11.00	6.8	1.8	8.6	8.7	.4	-.2	.5	.5	.4	.4	.92	.79	.1	.1
12.00	-3.7	-12.0	4.7	13.1	-.2	-.6	.3	.7	.2	.6	.85	-.54	.1	.1
13.00	.3	-1.0	8.9	9.2	-1.2	.4	10.4	6.5	1.6	.9	.68	.68	1.4	1.4
14.00	.5	-2.3	6.0	8.5	.0	-.2	.5	.6	.2	.3	.78	.59	1.2	1.2
15.00	3.6	23.1	9.2	36.0	-.4	-2.5	15.7	16.5	1.3	.3	.91	.82	2.0	2.0
16.00	-.1	-4.8	6.6	8.0	.5	-.8	4.1	6.1	.5	.8	.82	.82	.9	.9
17.00	10.4	7.6	12.6	11.8	.4	.2	.6	.4	.4	.3	.81	.66	1.3	1.3
18.00	14.0	5.5	14.0	5.5	.4	.2	.4	.2	.4	.2	.00	1.00	.0	.0
19.00	-2.9	4.8	7.6	12.9	-3.2	5.1	20.0	36.5	3.3	5.6	.87	.86	2.5	2.5
20.00	5.4	20.1	8.4	23.5	.2	1.0	.4	1.2	.3	1.0	.65	.60	.3	.3
21.00	22.2	22.7	23.0	23.4	.4	.4	.4	.4	.4	.4	.00	.81	.0	.0
22.00	-1.1	-12.6	3.1	14.2	-8.5	-35.0	20.0	81.3	8.5	35.0	.99	.99	.0	.0
23.00	4.3	3.8	7.6	9.1	.1	.1	.3	.4	.2	.3	-.10	-.25	.3	.3
24.00	18.8	22.7	19.0	22.9	.5	.6	.5	.6	.5	.6	.62	.40	.0	.0
25.00	20.0	17.0	22.8	17.3	.6	.5	.6	.5	.6	.5	****	1.00	.0	.0
26.00	3.8	.5	4.2	3.4	.1	.0	.2	.1	.1	.1	.29	-.52	.1	.1
27.00	16.9	23.4	17.1	23.6	.5	.6	.5	.6	.5	.6	.63	.67	.1	.1
28.00	2.3	-8.0	4.7	9.4	.1	-.8	.2	1.0	.2	.8	.88	.48	.0	.0
29.00	8.5	.4	10.0	4.4	.3	.0	.3	.2	.3	.1	.57	.71	.1	.1
30.00	.5	-3.2	7.3	8.2	.4	.2	3.6	3.5	-.2	-.1	.08	.12	.4	.4
31.00	-8.3	-13.0	9.0	13.5	-.7	-1.1	.8	1.2	.7	1.1	-.11	-.34	.1	.1
32.00	3.4	-3.8	3.8	5.2	.1	-.2	.1	.2	.1	.2	.78	-.51	.0	.0
33.00	2.3	-7.8	2.8	8.0	.1	-.3	.1	.3	.1	.3	.38	.00	.1	.1
34.00	6.2	2.4	10.1	7.5	.2	.0	.3	.2	.2	.2	.00	.72	.1	.1
35.00	16.0	10.7	20.0	15.1	.6	.4	.8	.6	.6	.4	.56	.66	.7	.7
36.00	1.0	.6	15.1	16.9	-7.1	-6.7	40.6	38.5	7.5	7.2	-.36	-.49	.9	.9
37.00	4.5	.2	16.4	16.9	-1.3	-1.4	19.6	18.4	2.1	1.9	.60	.53	4.0	4.0
38.00	8.6	-1.4	10.5	6.5	.3	-.1	.4	.3	.3	.2	.10	.31	.2	.2
39.00	.7	-3.7	7.5	8.6	-2.9	-3.3	23.5	24.7	3.3	3.5	.12	.43	.5	.5
42.00	19.5	11.3	20.1	12.1	.6	.4	.6	.4	.6	.4	.68	.80	.2	.2

Table E-3. Summary of results as a function of Circuit ID for the entire data base

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
- 43.00	19.2	15.9	22.0	20.0	1.6	.6	2.8	1.8	1.6	1.1	.54	.05	.1	.1
- 44.00	37.7	29.0	38.2	29.7	1.1	.8	1.1	.8	1.1	.8	.81	-.79	.0	.0
- 45.00	-1.0	.1	13.6	19.0	-.9	-.2	13.9	16.7	1.7	2.2	.56	.43	6.2	6.2
- 46.00	-24.2	-11.5	24.6	13.8	2.2	.6	2.6	.8	-2.2	-.7	.79	-.87	.0	.0
- 47.00	7.8	3.2	10.5	8.5	2.5	-.1	19.1	12.1	3.2	1.8	.70	.60	5.8	5.8
- 48.00	-2.9	-4.8	12.6	15.5	.3	.1	2.7	4.1	.2	.0	.70	.66	1.4	1.4
- 51.00	17.3	13.0	17.8	17.4	-1.4	.9	3.6	.9	-1.4	.3	.96	.12	.0	.0
- 52.00	6.4	.4	16.1	16.0	.4	-.6	11.9	22.8	1.7	2.8	.45	.42	3.5	3.5
- 53.00	-8.9	-6.1	16.2	20.8	-1.4	-2.0	14.3	23.9	1.6	2.8	.54	.50	5.3	5.3
- 54.00	9.4	.6	16.4	4.5	.7	.0	1.2	.4	.8	.3	-.13	-.14	.1	.1
- 55.00	40.2	34.9	40.9	35.5	1.0	.9	1.0	.9	1.0	.9	.10	.27	.1	.1
- 56.00	12.5	9.0	13.3	9.5	.5	.4	.6	.4	.5	.4	****	****	.0	.0
- 57.00	3.5	3.7	4.7	4.8	.1	.1	.2	.2	.1	.2	.55	.58	.2	.2
- 58.00	9.2	11.0	12.4	14.4	.3	.4	.5	.6	.5	.5	-.50	-.55	.1	.1
- 59.00	-4.7	.2	6.6	9.1	-.4	-.1	.6	.6	.4	.5	.55	-.65	.1	.1
- 60.00	-17.5	-21.0	18.6	22.1	-53.4	-68.2	77.1	98.3	53.4	68.2	****	****	.0	.0
- 61.00	-3.6	-2.7	10.5	9.7	-.8	-.3	3.8	2.5	1.1	.7	.75	.82	.1	.1
- 62.00	.7	2.0	7.3	6.8	-.2	-.1	.4	.3	.4	.3	.99	.96	.0	.0
- 63.00	-9.5	-9.8	10.2	10.5	-.9	-1.0	1.1	1.2	.9	1.0	-.04	-.09	.1	.1
- 64.00	6.7	8.7	8.0	10.4	.5	.7	.5	.8	.5	.7	.45	.16	.1	.1
- 65.00	6.0	5.5	6.7	6.2	.2	.2	.2	.2	.2	.2	.37	.37	.1	.1
- 66.00	-3.9	-1.0	14.8	16.2	.9	1.6	36.0	37.3	2.4	2.4	.33	.30	7.7	7.7
- 67.00	1.5	6.1	6.4	9.7	2.3	5.1	13.5	26.3	2.4	5.3	.68	.66	2.5	2.5
- 68.00	27.0	31.3	27.0	31.4	.8	.9	.8	.9	.8	.9	.97	.96	.0	.0
- 70.00	-15.4	-12.7	22.3	23.9	-1.4	-.8	19.6	23.7	1.5	2.3	.45	.28	5.8	5.8
- 71.00	11.5	16.0	11.8	16.2	.7	1.0	.7	1.0	.7	1.0	.00	.00	.0	.0
- 72.00	-2.5	-3.7	11.4	11.2	-38.1	-40.6	74.5	79.5	38.4	40.9	-.04	.49	.0	.0
- 73.00	-.3	-.9	12.1	12.2	1.8	1.8	5.0	5.1	-1.4	-1.5	.27	.25	.1	.1
- 74.00	11.1	10.9	13.3	12.5	1.8	1.6	3.1	2.7	1.8	1.6	.54	.41	.1	.1
- 75.00	5.8	9.0	6.2	9.3	.5	.8	.5	.8	.5	.8	.33	.33	.1	.1
- 76.00	.5	.5	12.5	9.5	-1.2	-.9	2.2	1.6	1.8	1.3	****	1.00	.0	.0
- 77.00	-12.1	-8.5	15.4	13.6	.4	.3	.5	.5	-.5	-.4	.01	.06	.4	.4
- 78.00	24.2	42.0	35.2	56.5	4.8	7.3	9.7	14.1	4.7	7.2	.53	.35	.0	.0
- 79.00	13.7	14.8	16.5	18.0	-3.0	-3.5	9.7	10.9	-3.0	-3.5	.16	-.01	.0	.0
- 80.00	-6.0	.8	18.8	26.0	-1.0	3.3	23.5	58.1	3.4	7.1	.36	.16	6.7	6.7
- 81.00	-.5	7.0	15.7	26.0	-.9	.1	11.1	21.5	1.3	3.8	.48	.28	1.4	1.4

Table E-4. Summary of results as a function of Circuit ID for the entire data base

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
1.00	11.5	11.5	18.3	14.8	.4	.4	.6	.5	.5	.4	.08	.09	.2	.2
2.00	-.6	-2.8	8.9	8.4	-.1	-.3	.6	.6	.5	.5	.41	.29	.4	.4
3.00	.7	-.8	9.6	8.1	-.1	-.2	.6	.6	.4	.4	.24	.23	1.2	1.2
5.00	8.5	28.2	14.9	43.7	2.4	6.2	28.4	76.6	4.0	7.3	.75	.71	7.1	7.1
6.00	3.8	8.0	13.7	12.9	2.9	4.3	18.2	22.7	4.5	5.3	.52	.60	.4	.4
7.00	33.1	24.2	35.0	25.5	.8	.6	.9	.6	.8	.6	.44	.25	.1	.1
8.00	8.1	24.8	15.3	41.9	4.4	8.2	24.4	69.0	3.8	7.9	.57	.58	2.7	2.7
9.00	1.0	7.8	18.4	36.8	1.7	1.7	3.4	5.9	-.6	-1.6	.21	.27	.5	.5
10.00	8.0	26.4	15.0	41.3	2.8	4.0	26.9	49.3	4.8	5.7	.74	.71	5.3	5.3
13.00	12.2	4.0	14.3	8.3	.7	.1	.9	.6	.7	.4	.78	.65	.2	.2
14.00	9.2	13.3	11.6	20.3	.9	.2	1.3	.9	.9	.7	.85	.03	.0	.1
15.00	4.6	25.1	9.2	38.8	-.5	-3.2	17.1	18.1	1.6	.2	.87	.81	1.7	1.7
17.00	23.2	22.7	24.8	24.1	.7	.6	.8	.7	.7	.6	.79	.59	.1	.1
19.00	-10.9	-6.7	11.8	8.3	-1.2	-.7	1.5	1.0	1.2	.7	-.38	.04	.1	.1
35.00	19.5	7.0	29.0	20.0	1.1	.7	1.2	1.0	.7	.4	.40	.49	.1	.1
37.00	-2.1	-15.3	23.8	27.5	.9	-.5	1.3	13.9	.0	.7	.48	.31	.8	.8
43.00	20.1	11.0	23.3	15.8	1.9	.3	3.3	2.3	2.0	1.4	.41	.17	.1	.1
45.00	-7.9	-17.9	16.6	23.0	-.7	1.1	7.2	3.6	.3	-.7	.26	-.14	1.0	.9
47.00	5.9	-.5	11.9	10.6	1.0	-2.4	4.3	19.8	.9	2.9	.37	.29	.4	.4
48.00	4.1	-9.8	14.3	17.5	.9	.7	1.9	1.4	.5	-.1	.75	.70	.3	.2
52.00	-20.7	-27.9	24.0	31.3	.9	-6.6	2.1	31.6	-.8	6.6	.37	.31	.3	.3
53.00	-12.4	-20.9	20.0	24.8	.2	.4	5.8	5.8	.5	-.3	.37	.47	.7	.6
61.00	-1.6	-3.9	11.3	12.1	.3	.9	1.1	1.0	.2	-.3	.92	.89	.1	.1
66.00	-5.8	-6.1	12.4	12.6	.4	.4	10.0	10.7	.7	.8	.44	.41	3.8	3.5
67.00	2.8	2.7	7.1	6.7	3.4	2.3	15.9	16.0	3.0	2.0	.47	.56	.5	.5
70.00	-55.5	-53.3	55.9	54.9	1.2	1.2	1.2	1.2	-1.2	-1.2	.86	-.52	.0	.0
77.00	-21.6	-17.7	22.6	20.1	.7	.6	.7	.7	-.7	-.6	.31	.29	.1	.1
80.00	-22.5	-25.2	25.4	27.7	.5	1.1	6.7	1.5	-.5	-1.1	.44	.36	1.2	1.0
81.00	-11.3	-15.5	12.9	16.2	-1.5	1.4	11.4	1.6	1.5	-1.4	.68	.73	.2	.1

Table E-5. Summary of results as a function of Circuit ID for Frequency-to-MUF ratio > 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
1.00	-1.1	15.6	4.8	16.4	-.1	.5	.2	.5	.2	.5	.58	.39	.2	.2
2.00	-10.0	-8.7	10.8	10.2	-2.7	-2.7	15.0	15.7	2.7	2.7	.92	.88	2.7	2.7
3.00	-2.7	1.2	7.9	8.4	-.2	.0	.6	.5	.3	.3	.68	.72	6.6	6.6
4.00	4.2	2.0	5.1	3.2	.1	.1	.2	.1	.1	.1	-.33	-.32	.0	.0
5.00	1.6	10.0	10.1	13.8	-.2	.3	2.3	1.8	.5	.6	.52	.67	2.5	2.5
6.00	7.3	19.7	8.0	19.8	.2	.6	.2	.6	.2	.6	-.99	.65	.0	.0
7.00	8.7	22.5	9.5	23.3	.2	.6	.2	.6	.2	.6	.52	.46	.4	.4
8.00	.1	6.5	7.8	12.5	-.1	.2	.4	.5	.3	.4	.45	.23	.7	.7
9.00	-13.9	-13.4	21.0	18.5	1.4	1.1	2.7	2.4	-1.2	-1.1	-.02	.33	.2	.2
10.00	-2.9	6.1	8.9	12.1	-.2	.7	10.2	9.4	.5	.9	.73	.77	2.5	2.5
11.00	5.5	.5	6.4	7.8	.3	-.2	.5	.5	.4	.4	.97	.86	.1	.1
12.00	-3.7	-12.0	4.7	13.1	-.2	-.6	.3	.7	.2	.6	.85	-.54	.1	.1
13.00	-1.6	-1.8	7.6	9.3	-1.5	.4	11.2	7.0	1.7	1.0	.77	.69	1.2	1.2
14.00	.2	-3.3	5.7	7.1	-.1	-.2	.5	.6	.2	.3	.79	.73	1.1	1.1
15.00	-1.0	13.1	9.4	16.9	.3	.5	2.7	.7	-.1	.6	.17	.57	.3	.3
16.00	-.7	-5.1	5.2	7.9	.5	-.8	4.2	6.2	.5	.9	.89	.85	.9	.9
17.00	9.5	6.0	11.2	9.8	.4	.1	.5	.4	.4	.3	.87	.76	1.2	1.1
18.00	14.0	5.5	14.0	5.5	.4	.2	.4	.2	.4	.2	.00	1.00	.0	.0
19.00	-2.7	5.1	7.5	13.0	-3.3	5.2	20.3	36.9	3.4	5.7	.88	.87	2.5	2.5
20.00	5.4	20.1	8.4	23.5	.2	1.0	.4	1.2	.3	1.0	.65	.60	.3	.3
21.00	22.2	22.7	23.0	23.4	.4	.4	.4	.4	.4	.4	.00	.81	.0	.0
22.00	-1.1	-12.6	3.1	14.2	-8.5	-35.0	20.0	81.3	8.5	35.0	.99	.99	.0	.0
23.00	4.3	1.0	7.6	6.6	.1	.0	.3	.3	.2	.2	-.10	-.04	.3	.2
24.00	18.8	22.7	19.0	22.9	.5	.6	.5	.6	.5	.6	.62	.40	.0	.0
26.00	3.8	.5	4.2	3.4	.1	.0	.2	.1	.1	.1	.29	-.52	.1	.1
27.00	16.9	23.4	17.1	23.6	.5	.6	.5	.6	.5	.6	.63	.67	.1	.1
28.00	2.3	-8.0	4.7	9.4	.1	-.8	.2	1.0	.2	.8	.88	.48	.0	.0
29.00	8.5	.4	10.0	4.4	.3	.0	.3	.2	.3	.1	.57	.71	.1	.1
30.00	.3	-3.3	7.4	8.3	.4	.2	3.7	3.6	-.2	-.1	-.10	.05	.4	.4
31.00	-8.3	-13.0	9.0	13.5	-.7	-1.1	.8	1.2	.7	1.1	-.11	-.34	.1	.1
32.00	3.4	-3.8	3.8	5.2	.1	-.2	.1	.2	.1	.2	.78	-.51	.0	.0
33.00	2.3	-7.8	2.8	8.0	.1	-.3	.1	.3	.1	.3	.38	.00	.1	.1
34.00	6.2	2.4	10.1	7.5	.2	.0	.3	.2	.2	.2	.00	.72	.1	.1
35.00	15.1	11.6	17.2	13.6	.4	.4	.7	.4	.6	.4	.50	.52	.6	.6
36.00	.6	.7	15.2	16.9	-7.4	-5.3	41.4	35.7	7.8	5.9	-.39	-.50	.8	.8
37.00	6.2	4.4	13.9	12.5	-1.9	-1.7	21.9	19.4	2.6	2.2	.14	.13	3.2	3.1
38.00	8.0	-2.4	9.7	5.1	.3	-.1	.3	.3	.3	.2	-.57	.58	.2	.2
39.00	.7	-3.7	7.5	8.6	-2.9	-3.3	23.5	24.7	3.3	3.5	.12	.43	.5	.5
42.00	19.5	11.3	20.1	12.1	.6	.4	.6	.4	.6	.4	.68	.80	.2	.2

Table E-6. Summary of results as a function of Circuit ID for Frequency-to-MUF ratio <= 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
43.00	16.5	22.3	17.8	24.3	.6	.9	.6	.9	.6	.9	-.08	-.06	.0	.1
45.00	.3	3.2	13.0	18.2	-.9	-.5	14.9	18.0	2.0	2.7	.54	.53	5.2	5.3
46.00	-22.5	-10.7	23.0	13.8	3.1	.5	3.4	.8	-3.1	-.7	1.00	-.92	.0	.0
47.00	8.0	3.5	10.4	8.3	2.6	.1	19.8	11.4	3.3	1.7	.73	.64	5.4	5.4
48.00	-4.6	-3.7	12.1	15.0	.2	.0	2.9	4.5	.1	.0	.71	.69	1.1	1.1
52.00	8.5	20.5	15.4	21.2	.3	.9	12.4	.9	1.9	.9	.48	****	3.3	.0
53.00	-8.4	2.5	15.6	14.2	-1.6	-.2	15.2	22.0	1.8	2.5	.51	.48	4.6	3.3
54.00	1.2	-4.2	3.9	20.2	.0	-2.3	.3	25.4	.2	3.3	.19	.55	.0	4.7
55.00	40.2	.6	40.9	4.5	1.0	.0	1.0	.4	1.0	.3	.10	-.14	.1	.1
57.00	3.5	34.9	4.7	35.5	.1	.9	.2	.9	.1	.9	.55	.27	.2	.1
58.00	9.2	3.7	12.4	4.8	.3	.1	.5	.2	.5	.2	-.50	.58	.1	.2
59.00	-4.7	11.0	6.6	14.4	-.4	.4	.6	.6	.4	.5	.55	-.55	.1	.1
61.00	-7.2	.2	8.7	9.1	-2.7	-.1	6.2	.6	2.7	.5	.73	-.65	.0	.1
62.00	.7	-1.6	7.3	6.6	-.2	-1.4	.4	3.4	.4	1.7	.99	.74	.0	.1
63.00	-9.5	2.0	10.2	6.8	-.9	-.1	1.1	.3	.9	.3	-.04	.96	.1	.0
64.00	7.2	-9.8	8.3	10.5	.5	-1.0	.6	1.2	.5	1.0	.56	-.09	.1	.1
65.00	6.0	8.7	6.7	10.4	.2	.7	.2	.8	.2	.7	.37	.16	.1	.1
66.00	-2.1	5.5	16.9	6.2	1.5	.2	49.6	.2	3.9	.2	.30	.37	3.9	.1
67.00	1.2	3.2	6.2	18.8	2.0	2.7	12.8	49.7	2.2	3.7	.72	.32	2.0	4.2
68.00	27.0	6.9	27.0	10.3	.8	5.8	.8	28.3	.8	6.1	.97	.71	.0	2.0
70.00	-15.2	31.3	21.9	31.4	-1.5	.9	19.7	.9	1.5	.9	.46	.96	5.8	.0
71.00	11.5	-12.5	11.8	23.6	.7	-.8	.7	23.8	.7	2.4	.00	.29	.0	5.8
73.00	-.3	16.0	12.1	16.2	1.8	1.0	5.0	1.0	-1.4	1.0	.27	.00	.1	.0
74.00	8.4	-.9	9.9	12.2	.7	1.8	.8	5.1	.7	-1.5	.65	.25	.1	.1
75.00	5.8	10.5	6.2	12.2	.5	.9	.5	1.0	.5	.9	.33	.22	.1	.1
77.00	-8.2	9.0	11.1	9.3	.3	.8	.5	.8	-.4	.8	.18	.33	.3	.1
78.00	30.4	-3.0	38.5	7.4	5.7	.1	10.6	.3	5.7	-.2	.99	.41	.0	.2
79.00	13.7	51.6	16.5	61.8	-3.0	8.7	9.7	15.5	-3.0	8.7	.16	.95	.0	.0
80.00	-2.5	14.8	17.1	18.0	-1.3	-3.5	25.7	10.9	4.2	-3.5	.42	-.01	5.5	.0
81.00	.9	5.2	16.0	25.7	-.8	3.6	11.1	62.8	1.3	8.5	.51	.27	1.2	5.7

Table E-7. Summary of results as a function of Circuit ID for Frequency-to-MUF ratio <= 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
-30.0--20.0	10.4	7.6	12.6	11.8	.4	.2	.6	.4	.4	.3	.81	.66	1.3	1.3
-20.0--10.0	9.3	3.9	17.2	11.6	.1	-.1	.8	.8	.7	.6	-.40	.28	.3	.3
-10.0- .0	5.8	9.0	6.2	9.3	.5	.8	.5	.8	.5	.8	.33	.33	.1	.1
.0- 10.0	5.4	3.5	15.7	15.7	.0	-.1	.6	.7	.5	.6	-.65	-.51	.6	.6
10.0- 20.0	-13.2	-11.4	21.3	23.0	-1.3	-1.0	18.7	23.6	1.5	2.4	.49	.39	6.5	6.5
20.0- 30.0	-1.1	1.1	16.9	22.3	-.6	1.4	18.9	44.1	2.5	4.9	.49	.43	13.1	13.1
30.0- 40.0	.2	-.2	9.4	9.1	.3	-.5	12.3	9.6	1.6	1.2	.75	.73	19.2	19.2
40.0- 50.0	5.5	2.9	15.8	16.1	-1.6	-1.3	20.0	18.6	2.3	2.0	.55	.44	7.8	7.8
50.0- 60.0	1.7	11.8	13.4	29.6	.7	2.3	19.2	42.6	2.5	3.9	.74	.63	43.0	43.0
60.0- 70.0	-4.4	-1.4	14.9	16.1	.9	1.6	35.1	36.3	2.2	2.2	.35	.32	8.1	8.1

Table E-8. Summary of results as a function of Midpath Latitude for entire data base

Conditions	Avg Residual		Rms Residual		Avg Rel Res		Rms Rel Res		Avg Abs Rel Res		Correlation		% of Total	
	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LFld	DBlt	LFld	DBlt
-30.0--20.0	23.2	22.7	24.8	24.1	.7	.6	.8	.7	.7	.6	.79	.59	.1	.1
10.0- 20.0	-33.3	-38.6	46.5	49.9	1.0	1.2	1.1	1.2	-.7	-.8	-.55	-.67	.0	.0
20.0- 30.0	-20.8	-22.7	24.1	27.0	.4	-.3	6.8	13.4	-.4	.3	.46	.52	1.6	1.4
30.0- 40.0	1.9	-.5	10.4	9.4	.2	-.6	1.9	8.5	.5	.9	.52	.46	2.1	2.1
40.0- 50.0	6.7	-6.4	24.5	24.4	.9	-1.1	1.2	16.8	.3	1.6	.58	.48	1.3	1.3
50.0- 60.0	6.1	21.1	15.0	39.4	2.3	4.3	24.1	57.8	3.4	5.2	.67	.58	20.6	20.3
60.0- 70.0	-6.3	-6.6	12.9	12.9	.4	.4	9.8	10.5	.7	.8	.45	.44	3.9	3.7

Table E-9. Summary of results as a function of Midpath Latitude for Frequency-to-MUF ratio > 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
-30.0--20.0	9.5	6.0	11.2	9.8	.4	.1	.5	.4	.4	.3	.87	.76	1.2	1.1
-20.0--10.0	9.3	3.9	17.2	11.6	.1	-.1	.8	.8	.7	.6	-.40	.28	.3	.3
-10.0- .0	5.8	9.0	6.2	9.3	.5	.8	.5	.8	.5	.8	.33	.33	.1	.1
.0- 10.0	5.4	3.5	15.7	15.7	.0	-.1	.6	.7	.5	.6	-.65	-.51	.6	.6
10.0- 20.0	-13.1	-11.2	21.0	22.7	-1.4	-1.0	18.8	23.6	1.5	2.4	.50	.40	6.5	6.5
20.0- 30.0	1.6	4.0	15.6	21.6	-.8	1.6	20.0	46.5	2.8	5.5	.53	.51	11.5	11.6
30.0- 40.0	.0	-.1	9.2	9.1	.3	-.5	13.0	9.7	1.7	1.3	.77	.75	17.2	17.2
40.0- 50.0	5.2	4.8	13.4	13.9	-2.1	-1.4	21.9	19.0	2.7	2.1	.33	.20	6.5	6.5
50.0- 60.0	-2.3	3.5	11.7	16.3	-.8	.6	13.3	21.1	1.6	2.7	.77	.67	22.4	22.7
60.0- 70.0	-2.6	2.8	16.6	18.3	1.4	2.5	47.8	48.2	3.6	3.4	.32	.34	4.2	4.4

Table E-10. Summary of results as a funciton of Midpath Latitude for Frequency-to-MUF ratio <= 1.0

Conditions (*1000 KM)	Avg Residual LtFld / DmBlt	Rms Residual LtFld / DmBlt	Avg Rel Res LtFld / DmBlt	Rms Rel Res LtFld / DmBlt	Avg Abs Rel Res LtFld / DmBlt	Correlation LFld / DBlt	% of Total LFld / DBlt
<= 1.00	2.5 / 13.4	12.6 / 29.9	1.1 / 2.5	18.9 / 44.8	2.3 / 3.5	.82 / .78	34.0 / 34.0
1.0= 2.0	1.7 / 6.9	8.8 / 19.5	-1.0 / .7	13.2 / 21.2	1.6 / 2.0	.87 / .83	9.7 / 9.7
2.0= 3.0	3.6 / .9	9.4 / 11.1	.2 / .1	2.2 / 2.2	.1 / .2	.04 / -.27	1.2 / 1.2
3.0= 4.0	5.4 / 1.5	16.5 / 16.4	-1.9 / -1.9	22.6 / 21.4	2.7 / 2.4	.53 / .45	5.8 / 5.8
4.0= 5.0	6.6 / .2	12.1 / 9.3	-1.3 / -1.8	17.8 / 18.7	2.3 / 2.1	.21 / .48	.9 / .9
5.0= 6.0	2.8 / 1.1	12.5 / 15.0	.7 / -.1	15.7 / 13.8	2.2 / 1.8	.56 / .50	13.5 / 13.5
6.0= 7.0	-2.4 / -3.2	16.5 / 19.1	-.7 / -1.4	13.3 / 23.3	1.6 / 2.8	.51 / .53	9.1 / 9.1
7.0= 8.0	1.3 / 2.9	9.3 / 10.4	-1.6 / -1.9	13.1 / 16.5	2.0 / 2.4	.67 / .58	.6 / .6
8.0= 9.0	.5 / 1.2	8.6 / 9.4	-.1 / .0	.8 / .8	.6 / .7	.35 / .34	.3 / .3
9.0= 10.0	-6.9 / -3.9	17.0 / 18.6	.2 / 1.2	28.0 / 31.2	2.1 / 2.9	.34 / .25	16.4 / 16.4
10.0= 11.0	-7.6 / -4.2	13.7 / 12.6	.4 / .4	.6 / .6	-.2 / -.1	.80 / .75	.5 / .5
12.0= 13.0	18.9 / 28.4	27.5 / 41.9	.9 / 1.9	9.7 / 12.6	.8 / 1.9	.46 / .15	.1 / .1
16.0= 17.0	-5.0 / 1.9	18.3 / 26.0	-1.0 / 2.7	21.9 / 53.7	3.0 / 6.5	.37 / .18	8.1 / 8.1

Table E-11. Summary of results as a function of Circult Length for entire data base

Conditions (*1000 KM)	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
.0= 1.0	7.5	23.3	15.0	39.8	2.6	5.0	25.1	61.4	3.7	5.9	.74	.72	17.9	17.9
1.0= 2.0	6.0	21.6	11.3	35.1	-.3	-2.5	15.4	16.0	1.5	.3	.87	.81	2.1	2.1
2.0= 3.0	13.0	10.9	18.2	13.6	.5	.3	.5	.4	.5	.4	-.23	.01	.0	.1
3.0= 4.0	1.5	-11.8	24.4	26.4	.9	-1.6	1.2	19.2	.2	1.9	.48	.32	1.0	1.0
4.0= 5.0	20.5	9.0	20.5	14.2	10.0	-.5	13.5	1.6	10.0	1.5	1.00	****	.0	.0
5.0= 6.0	-1.3	-10.8	16.3	19.6	.1	.2	5.8	10.0	.5	.3	.41	.30	1.8	1.6
6.0= 7.0	-13.1	-22.4	21.2	26.6	.4	-1.5	5.0	17.4	.1	1.6	.30	.42	1.0	.9
7.0= 8.0	-1.6	-3.9	11.3	12.1	.3	.9	1.1	1.0	.2	-.3	.92	.89	.1	.1
9.0= 10.0	-4.9	-5.3	12.9	12.9	.8	.6	10.7	11.4	1.0	1.0	.36	.33	4.4	4.1
10.0= 11.0	-21.6	-17.7	22.6	20.1	.7	.6	.7	.7	-.7	-.6	.31	.29	.1	.1
16.0= 17.0	-21.2	-24.2	24.3	26.8	.3	1.1	7.4	1.5	-.3	-1.1	.44	.37	1.3	1.1

Table E-12. Summary of results as a function of Circuit Length for Frequency-to-MUF ratio > 1.0

Conditions (*1000 KM)	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
.0= 1.0	-3.0	2.3	9.2	11.3	-.6	-.3	7.4	7.5	.8	.9	.65	.58	16.1	16.1
1.0= 2.0	.6	2.7	8.0	11.7	-1.2	1.5	12.6	22.4	1.6	2.5	.79	.74	7.6	7.5
2.0= 3.0	3.4	.0	9.2	10.8	.2	.0	2.3	2.3	.1	.2	.04	-.26	1.1	1.1
3.0= 4.0	6.2	4.3	14.4	13.4	-2.5	-2.0	24.8	21.8	3.2	2.5	.08	.06	4.8	4.8
4.0= 5.0	6.4	.0	11.9	9.2	-1.5	-1.8	17.9	18.9	2.1	2.1	.14	.47	.9	.9
5.0= 6.0	3.4	2.8	11.8	14.3	.8	-.2	16.7	14.3	2.4	2.0	.56	.57	11.7	11.9
6.0= 7.0	-1.0	-1.1	15.8	18.1	-.8	-1.4	14.0	23.8	1.8	2.9	.47	.57	8.1	8.2
7.0= 8.0	1.8	3.7	8.9	10.2	-1.9	-2.2	14.0	17.4	2.2	2.6	.30	.23	.5	.5
8.0= 9.0	.5	1.2	8.7	9.4	-.1	.0	.8	.8	.6	.7	.34	.34	.3	.3
9.0= 10.0	-7.7	-3.5	18.3	20.1	.0	1.4	32.1	35.4	2.5	3.5	.34	.25	12.0	12.3
10.0= 11.0	-3.7	1.0	10.0	8.1	.3	.3	.6	.6	-.1	.2	.88	.91	.4	.4
12.0= 13.0	21.3	31.5	28.7	43.7	1.0	2.1	10.1	13.2	1.0	2.1	.54	.23	.1	.1
16.0= 17.0	-1.9	5.8	16.9	25.9	-1.2	3.0	23.7	57.6	3.7	7.7	.43	.28	6.7	7.0

Table E-13. Summary of results as a function of Circuit Length for Frequency-to-MUF ratio <= 1.0

Conditions	Avg Residual LtFld / DmBlt	Rms Residual LtFld / DmBlt	Avg Rel Res LtFld / DmBlt	Rms Rel Res LtFld / DmBlt	Avg Abs Rel Res LtFld / DmBlt	Correlation LFld / DBlt	% of Total LFld / DBlt
<= 1.00	-2.2 / 2.1	15.4 / 27.6	-1.2 / .3	23.7 / 41.1	3.9 / 5.5	.66 / .56	4.0 / 4.0
1.0- 2.0	-3.5 / .4	16.3 / 27.4	-2.0 / -2.6	17.1 / 19.0	2.0 / 1.7	.64 / .54	3.9 / 3.9
2.0- 3.0	-3.0 / -.3	16.9 / 28.7	-1.7 / -1.7	25.4 / 37.6	3.9 / 5.0	.62 / .53	3.8 / 3.8
3.0- 4.0	-2.4 / 1.9	16.9 / 31.4	-.1 / .6	24.2 / 49.7	3.3 / 5.6	.62 / .51	3.6 / 3.6
4.0- 5.0	-3.5 / 3.0	17.0 / 32.2	-.2 / 1.7	21.8 / 54.6	2.4 / 4.8	.62 / .51	3.4 / 3.4
5.0- 6.0	-5.2 / 1.3	15.8 / 29.1	-1.0 / -1.9	23.7 / 37.4	2.8 / 2.9	.69 / .52	3.3 / 3.3
6.0- 7.0	-4.0 / -1.2	13.2 / 23.8	-.9 / -2.4	13.6 / 18.2	1.0 / 1.4	.78 / .64	4.0 / 4.0
7.0- 8.0	-4.0 / -.2	12.4 / 24.0	-.8 / -1.8	14.7 / 17.3	1.5 / 1.6	.78 / .62	3.4 / 3.4
8.0- 9.0	-1.9 / -1.3	11.9 / 17.1	.3 / .6	5.9 / 14.3	.7 / 1.0	.77 / .67	3.7 / 3.7
9.0- 10.0	.2 / 2.0	12.3 / 15.2	.7 / 2.2	10.8 / 33.7	1.1 / 2.1	.75 / .70	3.6 / 3.6
10.0- 11.0	2.0 / 5.9	11.9 / 15.0	1.3 / .5	15.1 / 12.8	2.1 / 1.6	.77 / .72	3.7 / 3.7
11.0- 12.0	2.5 / 7.6	12.2 / 16.4	1.0 / 1.4	16.0 / 13.4	1.9 / 1.6	.76 / .71	4.2 / 4.2
12.0- 13.0	2.2 / 9.2	13.3 / 18.4	-.7 / .6	19.9 / 25.4	2.7 / 3.0	.72 / .67	4.1 / 4.1
13.0- 14.0	3.0 / 10.6	13.7 / 19.5	1.8 / 4.2	46.9 / 50.1	4.0 / 5.1	.69 / .65	4.3 / 4.3
14.0- 15.0	2.8 / 11.5	13.3 / 19.9	.4 / .5	12.0 / 13.4	1.5 / 1.5	.69 / .64	4.3 / 4.3
15.0- 16.0	1.8 / 10.5	12.0 / 17.9	1.2 / 3.4	14.0 / 26.5	1.5 / 3.3	.74 / .68	4.5 / 4.5
16.0- 17.0	1.8 / 9.4	12.2 / 18.3	.5 / 2.0	10.2 / 24.2	1.2 / 2.2	.75 / .66	4.5 / 4.5
17.0- 18.0	1.1 / 7.2	12.5 / 18.2	.6 / 1.3	10.6 / 20.8	1.0 / 1.3	.75 / .69	5.2 / 5.2
18.0- 19.0	2.6 / 6.0	15.2 / 19.8	-.3 / .1	17.7 / 20.2	2.3 / 2.2	.70 / .69	4.9 / 4.9
19.0- 20.0	3.4 / 5.4	16.2 / 22.8	.7 / 3.1	18.5 / 44.2	2.2 / 4.2	.69 / .66	5.2 / 5.2
20.0- 21.0	2.2 / 4.9	14.8 / 26.0	1.9 / 6.4	24.6 / 72.0	3.0 / 6.6	.70 / .61	5.0 / 5.0
21.0- 22.0	1.0 / 4.4	14.2 / 25.2	-.4 / 1.2	17.0 / 43.4	1.9 / 3.0	.70 / .61	4.7 / 4.7
22.0- 23.0	-.2 / 3.3	14.7 / 26.3	.9 / 1.7	16.6 / 33.1	2.0 / 3.1	.68 / .59	4.5 / 4.5
23.0- 24.0	-1.3 / 2.9	15.2 / 27.2	.0 / .8	15.4 / 25.5	1.8 / 2.4	.67 / .58	4.1 / 4.1

Table E-14. Summary of results as a function of Local Time for entire data base

Conditions	Avg Residual LtFld / DmBlt	Rms Residual LtFld / DmBlt	Avg Rel Res LtFld / DmBlt	Rms Rel Res LtFld / DmBlt	Avg Abs Rel Res LtFld / DmBlt	Correlation LFld / DBlt	% of Total LFld / DBlt
1.0- 1.0	2.0 / 15.7	16.0 / 40.7	2.9 / 4.9	20.7 / 48.9	3.4 / 5.7	.60 / .49	1.4 / 1.4
1.0- 2.0	.8 / 14.7	16.5 / 40.2	-1.2 / -2.6	15.8 / 18.8	.8 / -.3	.57 / .46	1.5 / 1.4
2.0- 3.0	1.1 / 14.1	17.0 / 40.5	2.5 / 4.4	17.9 / 44.7	2.1 / 3.9	.58 / .45	1.8 / 1.5
3.0- 4.0	2.4 / 13.4	17.1 / 40.7	3.2 / 4.1	23.8 / 65.5	2.8 / 7.9	.62 / .44	1.8 / 1.8
4.0- 5.0	2.6 / 16.5	16.6 / 40.8	1.5 / 6.6	25.1 / 71.6	2.8 / 5.7	.59 / .54	1.6 / 1.8
5.0- 6.0	-.9 / 12.5	15.2 / 36.6	1.1 / -.4	26.5 / 45.1	3.1 / 2.1	.47 / .50	1.3 / 1.7
6.0- 7.0	-2.4 / 12.2	13.9 / 34.1	-1.1 / -3.4	12.0 / 20.0	.6 / .6	.61 / .54	1.1 / 1.5
7.0- 8.0	-5.2 / 15.7	12.8 / 39.1	-1.7 / -2.2	24.3 / 21.0	2.8 / 1.6	.67 / .49	.8 / 1.1
8.0- 9.0	-3.3 / 5.9	12.6 / 28.4	1.2 / 2.1	9.9 / 27.0	1.2 / 1.9	.68 / .43	.8 / .9
9.0- 10.0	.7 / 7.1	12.8 / 24.2	2.8 / 6.9	21.0 / 66.9	2.3 / 5.7	.68 / .52	.8 / .9
10.0- 11.0	2.6 / 8.0	13.0 / 22.8	.8 / .9	2.5 / 4.6	.0 / -.2	.70 / .52	.7 / .8
11.0- 12.0	4.3 / 8.6	13.9 / 21.9	1.0 / 1.2	3.4 / 5.4	.0 / -.1	.70 / .54	.7 / .7
12.0- 13.0	3.9 / 10.0	12.5 / 22.1	-2.1 / -1.5	24.9 / 19.7	2.6 / 1.6	.73 / .56	.7 / .7
13.0- 14.0	4.0 / 8.9	12.9 / 21.1	-1.6 / -.9	22.8 / 18.6	2.2 / 1.3	.70 / .54	.8 / .8
14.0- 15.C	3.8 / 10.1	13.0 / 21.7	-.2 / -.8	11.8 / 15.4	2.3 / 2.2	.70 / .55	.9 / .8
15.0- 16.0	2.6 / 9.0	13.4 / 22.0	1.5 / 1.7	9.0 / 12.5	1.6 / 1.9	.65 / .55	1.0 / .9
16.0- 17.0	3.9 / 8.6	12.9 / 23.9	2.4 / 5.2	16.7 / 46.5	2.9 / 5.2	.70 / .52	1.2 / 1.0
17.0- 18.0	6.0 / 9.5	14.6 / 25.5	2.7 / 4.3	19.0 / 43.3	2.9 / 4.2	.69 / .53	1.3 / 1.1
18.0- 19.0	8.5 / 12.6	18.5 / 30.0	3.0 / 2.6	19.6 / 21.8	3.1 / 2.4	.62 / .51	1.4 / 1.1
19.0- 20.0	7.6 / 16.1	19.1 / 35.4	4.0 / 9.6	27.9 / 84.3	4.2 / 10.4	.50 / .47	1.5 / 1.2
20.0- 21.0	6.2 / 13.6	18.3 / 36.8	3.1 / 8.2	26.0 / 80.1	3.7 / 7.6	.57 / .40	1.6 / 1.4
21.0- 22.0	4.4 / 15.2	16.8 / 37.2	1.3 / 5.8	20.6 / 75.2	2.2 / 5.3	.60 / .48	1.6 / 1.4
22.0- 23.0	1.8 / 13.6	16.1 / 38.6	4.2 / 6.4	24.7 / 51.3	3.7 / 5.8	.60 / .45	1.5 / 1.5
23.0- 24.0	1.5 / 14.6	16.6 / 39.2	1.9 / 1.7	17.5 / 24.0	2.6 / 2.4	.59 / .48	1.5 / 1.4

Table E-15. Summary of results as a function of Local Time for Frequency-to-MUF ratio > 1.0

Conditions	Avg Residual LtFld / DmBlt	Rms Residual LtFld / DmBlt	Avg Rel Res LtFld / DmBlt	Rms Rel Res LtFld / DmBlt	Avg Abs Rel Res LtFld / DmBlt	Correlation LFld / DBlt	% of Total LFld / DBlt
1.0- 1.0	-4.6 / -5.4	15.0 / 16.2	-3.6 / -2.2	25.2 / 36.0	4.1 / 5.5	.56 / .53	2.5 / 2.6
1.0- 2.0	-6.0 / -7.5	16.1 / 16.3	-2.6 / -2.6	17.8 / 19.1	2.8 / 2.8	.60 / .62	2.5 / 2.5
2.0- 3.0	-6.5 / -9.4	16.8 / 17.3	-5.3 / -5.5	30.5 / 32.2	5.5 / 5.6	.54 / .67	2.1 / 2.3
3.0- 4.0	-7.4 / -9.9	16.7 / 17.3	-3.5 / -3.1	24.6 / 24.6	3.8 / 3.2	.57 / .68	1.8 / 1.8
4.0- 5.0	-9.3 / -12.0	17.3 / 18.7	-1.8 / -3.8	18.2 / 24.4	2.0 / 3.9	.66 / .72	1.7 / 1.6
5.0- 6.0	-8.1 / -10.9	16.1 / 17.7	-2.4 / -3.6	21.6 / 26.6	2.6 / 3.7	.69 / .72	2.0 / 1.6
6.0- 7.0	-4.6 / -9.1	12.9 / 14.4	-.8 / -1.9	14.2 / 17.1	1.2 / 1.9	.73 / .80	2.9 / 2.5
7.0- 8.0	-3.6 / -7.2	12.2 / 12.6	-.5 / -1.6	9.8 / 15.3	1.0 / 1.6	.76 / .82	2.6 / 2.4
8.0- 9.0	-1.5 / -3.7	11.7 / 11.1	.0 / .1	4.1 / 5.3	.5 / .7	.76 / .81	2.9 / 2.8
9.0- 10.0	.1 / .3	12.1 / 10.8	.1 / .7	5.6 / 8.6	.8 / 1.0	.76 / .80	2.9 / 2.8
10.0- 11.0	1.8 / 5.3	11.6 / 12.3	1.5 / .3	16.8 / 14.2	2.6 / 2.1	.78 / .80	3.0 / 3.0
11.0- 12.0	2.1 / 7.3	11.9 / 14.9	1.0 / 1.4	17.6 / 14.5	2.4 / 2.0	.77 / .75	3.4 / 3.4
12.0- 13.0	1.9 / 9.0	13.4 / 17.5	-.4 / 1.1	18.7 / 26.5	2.8 / 3.3	.72 / .70	3.4 / 3.4
13.0- 14.0	2.8 / 11.0	13.9 / 19.0	2.7 / 5.4	51.0 / 54.9	4.4 / 6.0	.68 / .68	3.4 / 3.5
14.0- 15.0	2.5 / 11.9	13.4 / 19.5	.5 / .8	12.1 / 12.9	1.2 / 1.3	.68 / .66	3.4 / 3.5
15.0- 16.0	1.5 / 10.8	11.5 / 16.6	1.1 / 3.9	15.2 / 29.0	1.5 / 3.7	.75 / .73	3.4 / 3.6
16.0- 17.0	1.0 / 9.6	11.9 / 16.4	-.2 / 1.1	6.5 / 12.2	.6 / 1.4	.74 / .71	3.3 / 3.5
17.0- 18.0	-.6 / 6.5	11.7 / 15.5	-.1 / .5	5.2 / 4.9	.3 / .5	.74 / .73	3.9 / 4.1
18.0- 19.0	.1 / 4.0	13.6 / 15.6	-1.8 / -.7	16.9 / 19.7	2.0 / 2.1	.72 / .73	3.5 / 3.8
19.0- 20.0	1.6 / 2.0	14.8 / 16.9	-.8 / 1.1	12.4 / 18.0	1.4 / 2.2	.69 / .70	3.6 / 3.9
20.0- 21.0	.3 / 1.7	12.8 / 20.5	1.4 / 5.7	24.0 / 68.7	2.6 / 6.2	.68 / .62	3.4 / 3.6
21.0- 22.0	-.8 / -.3	12.7 / 17.5	-1.4 / -.8	14.7 / 15.5	1.7 / 2.0	.64 / .59	3.1 / 3.3
22.0- 23.0	-1.3 / -1.8	13.9 / 17.2	-.8 / -.6	10.0 / 18.2	1.1 / 1.7	.56 / .54	2.9 / 3.0
23.0- 24.0	-2.9 / -3.5	14.4 / 17.6	-1.1 / .4	14.1 / 26.3	1.4 / 2.4	.57 / .52	2.6 / 2.7

Table E-16. Summary of results as a function of Local Time for Frequency-to-MUF ratio <= 1.0

Conditions	Avg Residual		Rms Residual		Avg Rel Res		Rms Rel Res		Avg Abs Rel Res		Correlation		% of Total	
	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LFld	DBlt	LFld	DBlt
=1 (N & S)	-3.0	-1.2	10.1	11.7	-.6	-.4	7.4	7.3	.9	.7	.65	.62	14.0	14.0
=2 (E & W)	3.7	16.6	12.4	31.7	1.1	3.3	21.0	47.2	2.8	4.3	.82	.74	27.1	27.1
=0 (other)	-.9	.6	15.8	20.4	-.1	.4	21.1	32.2	2.2	3.0	.58	.50	58.8	58.8

Table E-17. Summary of results as a function of Orientation for entire data base

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
=1 (N & S)	1.5	1.2	12.4	18.8	.4	.3	1.7	2.8	.2	-.1	.63	.56	2.3	2.3
=2 (E & W)	7.3	24.6	14.4	40.4	2.2	4.1	25.7	59.6	3.8	5.5	.74	.69	15.6	15.6
=0 (other)	-3.2	-1.9	17.9	27.2	1.3	2.0	13.4	35.4	1.2	2.4	.38	.23	11.7	11.1

TableE-18. Summary of results as a function of Orientation for Frequency-to-MUF ratio > 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
=1 (N & S)	-3.9	-1.7	9.5	9.7	-.8	-.5	8.1	7.9	1.0	.9	.63	.64	11.7	11.7
=2 (E & W)	-1.2	5.9	9.0	12.9	-.4	2.3	11.9	21.3	1.3	2.7	.86	.81	11.5	11.6
=0 (other)	-.4	1.2	15.2	18.4	-.5	.0	22.6	31.4	2.4	3.2	.58	.55	47.1	47.7

Table E-19. Summary of results as a function of Orientation for Frequency-to-MUF ratio <= 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
=1 (Winter)	-.5	8.7	16.4	30.0	.8	2.3	25.8	43.7	2.2	3.6	.66	.57	23.5	23.5
=2 (Spring)	-1.2	1.3	13.1	19.3	-.1	.3	16.1	21.1	1.7	1.9	.72	.65	24.6	24.6
=3 (Summer)	.2	3.2	12.3	17.7	.0	.3	16.0	23.8	2.1	2.6	.77	.68	25.3	25.3
=4 (Fall)	1.5	5.7	14.9	24.0	-.1	1.3	19.8	44.3	2.5	4.1	.65	.55	26.6	26.6

Table E-20. Summary of results as a function of Season for entire data base

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
=1 (Winter)	3.3	16.6	15.6	39.3	1.7	2.1	16.3	35.9	1.9	2.3	.67	.54	9.8	9.6
=2 (Spring)	-1.0	6.6	14.7	29.1	.3	1.4	26.2	33.7	3.6	3.4	.51	.47	5.9	5.8
=3 (Summer)	-.3	7.9	13.3	27.1	1.8	1.8	14.5	34.4	1.8	3.1	.66	.46	5.9	5.9
=4 (Fall)	7.0	15.6	18.3	36.7	2.7	6.1	23.8	75.2	3.0	6.8	.56	.44	8.0	7.7

Table E-21. Summary of results as a function of Season for Frequency-to-MUF ratio > 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
=1 (Winter)	-3.1	3.2	16.9	21.4	.1	2.5	30.8	48.3	2.5	4.5	.58	.53	13.7	14.0
=2 (Spring)	-1.3	-.4	12.6	15.0	-.2	.0	11.0	15.2	1.1	1.5	.73	.70	18.7	18.8
=3 (Summer)	.3	1.8	11.9	13.7	-.6	-.1	16.4	19.5	2.2	2.4	.76	.74	19.4	19.4
=4 (Fall)	-.8	1.7	13.2	16.2	-1.2	-.7	17.8	21.7	2.3	2.9	.67	.60	18.6	18.9

Table E-22 Summary of results as a function of Season for Frequence-to-MUF ratio <= 1.0

Conditions	Avg Residual LtFld	Avg Residual DmBlt	Rms Residual LtFld	Rms Residual DmBlt	Avg Rel Res LtFld	Avg Rel Res DmBlt	Rms Rel Res LtFld	Rms Rel Res DmBlt	Avg Abs Rel Res LtFld	Avg Abs Rel Res DmBlt	Correlation LFld	Correlation DBlt	% of Total LFld	% of Total DBlt
<= 30.00	-4.0	5.5	16.3	27.4	.1	1.4	17.6	39.9	1.8	3.4	.64	.50	16.3	16.3
30.0- 60.0	-1.3	4.0	14.9	23.0	-.9	.5	27.4	31.5	2.8	3.4	.66	.55	22.6	22.6
60.0- 90.0	-.3	2.2	12.9	18.4	.4	.6	14.3	22.6	1.7	2.3	.73	.67	20.1	20.1
90.0-120.0	4.1	8.1	13.4	24.6	.9	2.6	18.4	50.1	2.1	3.9	.76	.62	16.2	16.2
120.0-150.0	2.2	5.2	13.4	22.8	.5	1.2	16.8	35.2	2.1	3.3	.72	.63	15.0	15.0
150.0-180.0	.6	3.7	13.9	22.7	.3	.1	17.8	21.1	2.1	1.6	.71	.63	9.8	9.8

TableE-23. Summary of results as a function of Smoothed Sunspot Number for entire data base

Conditions	Avg Residual LtFld / DmBlt	Rms Residual LtFld / DmBlt	Avg Rel Res LtFld / DmBlt	Rms Rel Res LtFld / DmBlt	Avg Abs Rel Res LtFld / DmBlt	Correlation LFld / DBlt	% of Total LFld / DBlt
1.0- 30.0	-1.5 / 14.9	14.7 / 37.0	.5 / -.4	16.4 / 26.2	1.8 / 1.3	.66 / .52	4.8 / 4.7
30.0- 60.0	.6 / 11.2	15.3 / 33.3	.6 / .7	20.5 / 28.4	2.4 / 2.8	.64 / .53	5.6 / 5.4
60.0- 90.0	-1.4 / 5.7	14.5 / 28.6	2.2 / 2.9	22.2 / 36.6	3.2 / 3.9	.59 / .50	4.1 / 4.0
90.0-120.0	7.7 / 16.0	16.6 / 36.3	3.2 / 7.9	24.6 / 79.2	3.1 / 7.7	.63 / .44	6.3 / 6.2
120.0-150.0	6.0 / 14.2	16.5 / 35.0	1.9 / 3.6	19.1 / 52.8	2.6 / 4.6	.59 / .45	5.4 / 5.2
150.0-180.0	2.6 / 10.8	16.5 / 34.7	1.3 / 1.3	17.2 / 28.5	1.7 / 1.1	.56 / .44	3.5/ 3.4

Table E-24. Summary of results as a function of Smoothed Sunspot Number for Frequency-to-MUF ratio > 1.0

Conditions	Avg Residual		Rms Residual		Avg Rel Res		Rms Rel Res		Avg Abs Rel Res		Correlation		% of Total	
	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LtFld	DmBlt	LFld	DBlt	LFld	DBlt
1.0- 30.0	-5.0 /	1.7	16.9 /	22.3	-.1 /	2.1	18.1 /	44.4	1.9 /	4.2	.60 /	.45	11.5 /	11.5
30.0- 60.0	-2.0 /	1.8	14.8 /	18.7	-1.4 /	.4	29.3 /	32.5	3.0 /	3.6	.63 /	.54	17.0 /	17.2
60.0- 90.0	.0 /	1.3	12.5 /	14.8	-.1 /	.0	11.4 /	17.5	1.3 /	1.9	.71 /	.70	16.1 /	16.2
90.0-120.0	1.8 /	3.1	10.8 /	12.8	-.6 /	-.7	13.0 /	13.6	1.5 /	1.5	.78 /	.76	9.9 /	10.0
120.0-150.0	.1 /	.3	11.3 /	11.8	-.4 /	-.1	15.3 /	20.1	1.9 /	2.6	.75 /	.77	9.5 /	9.7
150.0-180.0	-.5 /	-.1	12.2 /	12.1	-.3 /	-.5	18.1 /	15.8	2.2 /	1.8	.73 /	.77	6.3 /	6.4

TableE-25. Summary of results as a function of Smoothed Sunspot Number for Frequency-to-MUF ratio <= 1.0

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The purpose of this document is to provide information about the special operations radio frequency management system (SORFMS) model enhancements. The enhancements include the incorporation of a sounder update (SU) model and an improved version of the field strength (FS) model. The SU model is an adaptation and translation to FORTRAN of the Army PROPHET evaluation system (APES) BASIC model. The FS enhancements involve modification of the field strength modeling algorithms, consequential to efforts to improve the accuracy of this model.

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